VARIAN

Recorder Division

TECHNICAL INFORMATION

VARIAN ASSOCIATES
PALO ALTO, CALIFORNIA

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Model G-11A
Strip-Chart Recorder

VARIAN associates

RECORDER DIVISION

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introduction

Figure 1-1: The Varian Model G-11A Strip-Chart Recorder

1.0 INTRODUCTION

1.1 DESCRIPTION

The Model G-11A Strip Chart Recorder is a self-contained instrument for recording phenomena which can be translated into slow changes of voltage or current. It is a true rectilinear recorder, operating on the automatic null-seeking principle.

Either portable or panel-mounting versions of the G-11A are available. The user may change from one version to another by changing mounting hardware. See Section 1.7.5 for details of panel mounting. Mounting panels are available for single recorder mounting or side-by-side mounting of two recorders in 19-inch racks.

Six different types of input chassis are available for the G-11A, adapting it to a variety of input signals. These input chassis may be readily exchanged by the user in the field, thus extending the usefulness of the instrument. Section 1.4 describes the input chassis types available.

Two modes of writing are offered: ink and inkless. Inks are available in a number of colors and types, allowing proper ink selection for a wide range of writing speeds and reproduction requirements. Inkless writing is achieved by scribing special wax-coated paper with a stylus. See Recorder Supply Catalog for inks, pens, charts, stylii, and inkless paper.

The standard G-11A Recorder is equipped with a single chart motor providing the chart speed specified at the time of purchase. Optional versions are available with two chart motors, a special high-speed chart motor, and a mechanical speed shifter which makes possible as many as four chart speeds. Sections 1.7.1 and 1.7.2 show the details of the options offered.

The G-11A also features event markers for both a-c and d-c energizing voltages in ink- and inkless-recording versions. Section 1.7.3 describes the available variations.

All options and accessories can be replaced or added in the field. See Section 1.7 for accessories.

1.2 THE POTENTIOMETER METHOD

The G-11A Recorder uses the potentiometric method for accurate voltage measurement, the principle of which is explained in Figure 1-2. First, assume that arm F is at its lowest point, E. A precision potentiometer, the SLIDEWIRE, is used to adjust the output from internal voltage source BT. When a voltage developed between points F and G, is made exactly equal and opposite to the signal voltage between points A and B by adjustment of arm G, no voltage will appear at the terminals C and D, nor will there be a current flow through the signal source. Thus the position of the slidewire arm G will be proportional to the signal voltage.

Moving arm F to a new position necessitates corresponding repositioning of arm G to restore zero output voltage at terminals C and D. Hence, the control F is called the ZERO ADJUST, as it is used for setting the initial position of slidewire arm G.

The advantage of the potentiometric method lies in the fact that it permits accurate voltage measurement without drawing any energy from the measured source.

1.3 EQUIPMENT SUPPLIED

Model G-11A Recorder is delivered with the ordered input chassis installed. Unless ordered differently, the recorder is supplied with the following items:

(1) G-11A Recorder
(2) Type 720B recorder pen
(3) Pen cleaner, Type 721
(4) 1-oz. bottle of red recorder ink
(5) Roll of #5A chart paper
(6) Take-up core, Part #901279
(7) Spare reference cell (if used)
(8) Instruction Manual

1.4 INPUT CHASSIS

The various input chassis available for the G-11A are designed to filter and adapt input signals to the basic potentiometer measuring method used in the Model G-11A Recorder. These input chassis are as follows:

1.4.1 Type A1 Millivolt Input Chassis

This input chassis is designed for input signals from 9 to 100 millivolts full-span. The reference voltage is obtained from a mercury cell.

1.4.2 Type A2 Millivolt Input Chassis

The input chassis is the same as Type A1 except that it employs an electronic voltage supply for reference voltage instead of a mercury cell.

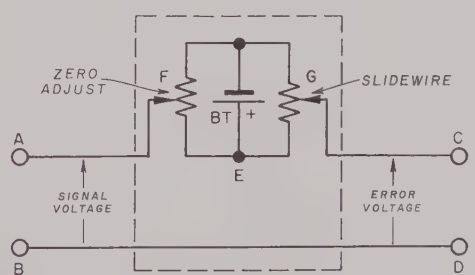


Figure 1-2: Potentiometric Measuring Circuit

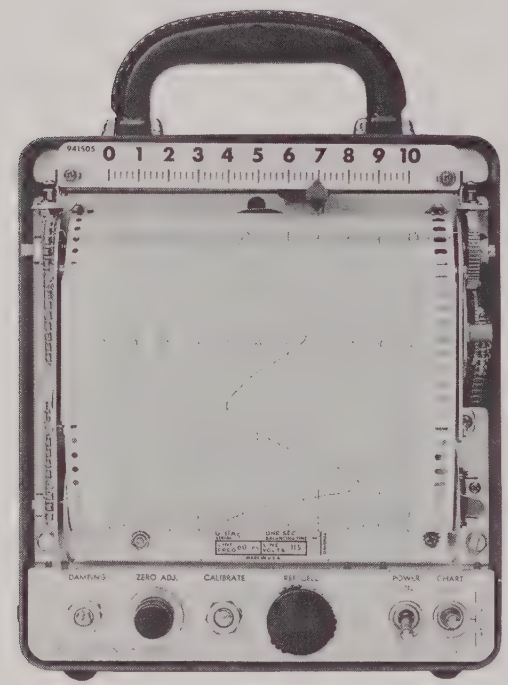


Figure 1-3: G-11A Recorder with Type A1 Millivolt Input Chassis

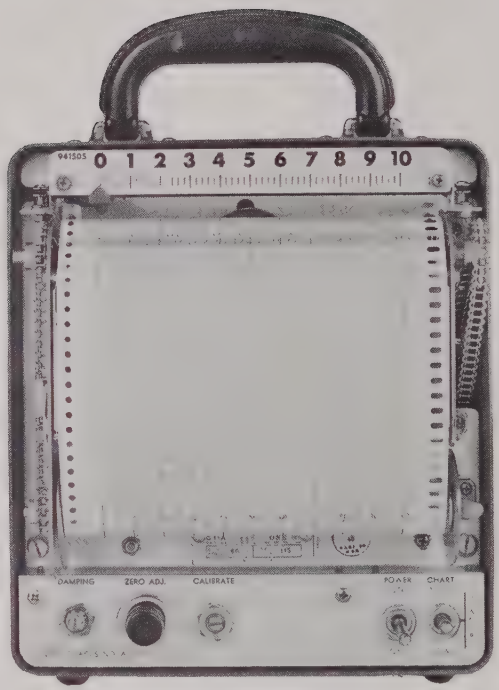


Figure 1-4: G-11A Recorder with Type A2 Millivolt Input Chassis

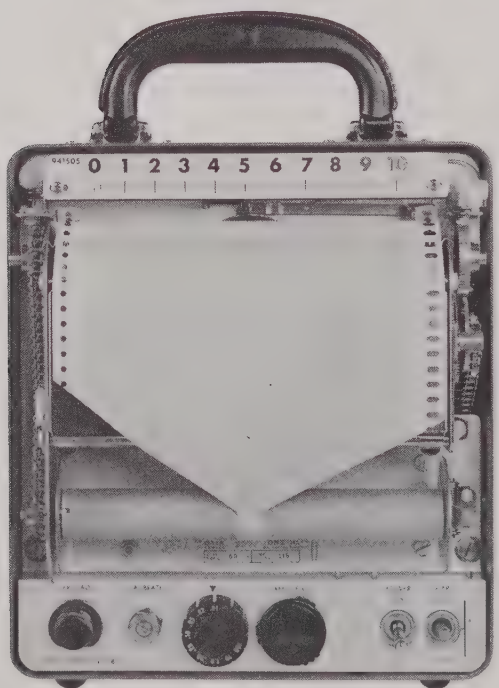


Figure 1-5: G-11A Recorder with Type B1 Wide-Range Input Chassis

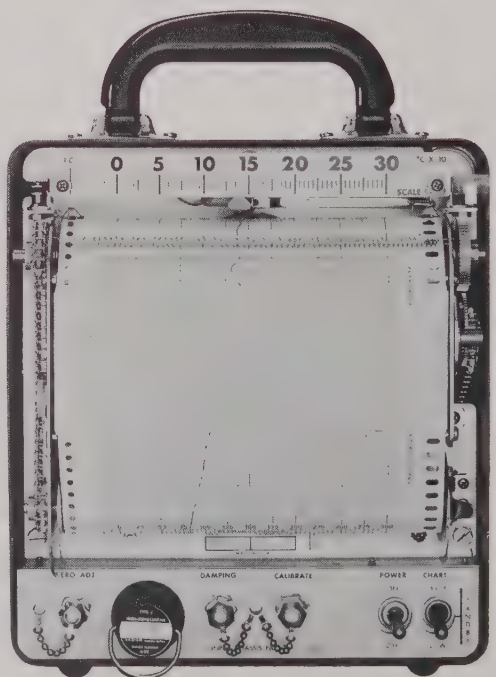


Figure 1-6: G-11A Recorder with Type T2 Thermocouple Input Chassis

1.4.3 Type B1 Wide-Range Input Chassis

Type B1 Input Chassis allows recording of signals from 10 millivolts to 100 volts full scale in nine steps or ranges of 10, 20, 50, 100, 200, 500 mv, and 1, 10, 100 volts. In the 10-millivolt range the input attenuator is bypassed.

1.4.4 Type F1 Current Input Chassis

Type F1 Input Chassis is designed to record input signals of 1 milliampere full scale. This chassis presents a 1350-ohm resistance to the input signal source.

1.4.5 Type T2 Thermocouple Input Chassis

Designed for temperature recording from thermocouple inputs, this input chassis adapts the recorder to different temperature ranges and thermocouple types through use of plug-in range elements. The chassis employs automatic reference junction compensation, and uses an electronic reference voltage supply.

1.4.6 Type X1 Blank Input Chassis

Type X1 Input Chassis contains only the standard terminals and sockets. This chassis allows the user to construct an input circuit of his own design.

1.5 GLOSSARY OF TERMS

The following terms are used to describe performance and operation of the Model G-11A Recorder:

Span (full span)	Algebraic difference between the top scale value and the bottom scale value of the quantity being measured.
Range (measurement range)	Region covered by span and expressed by stating two end-scale values. Example: 0 to 100 millivolts; 5-0-5 volts.
Limit of Error	Difference between the indicated and true value of measured quantity. (Does not include transducer errors.)
Dead Band	Range through which measured quantity may be varied without instrument response.
Full Span Balancing Time	Time required for the instrument to achieve a full-span change of pen deflection when a full-span step-input signal is applied to the input terminals.
Input Signal	Signal at recorder input terminals and proportional to actual quantity being measured.
Signal Voltage	Voltage proportional to input signal which is being cancelled by measuring voltage. In millivolt input chassis types it is equal to input signal.
Reference Voltage	A stable voltage supplied by battery or electronic voltage supply in the recorder and used as a source for measuring voltage.
Measuring Voltage	Part of the reference voltage used to cancel or balance the signal voltage.
Error Voltage	Difference between signal voltage and measuring voltage.
Balancing Voltage	Error voltage modulated by the chopper and applied to the servo amplifier.

1.6 GENERAL SPECIFICATIONS

The following specifications apply to the Model G-11A Recorder equipped with any input chassis:

Dimensions	Portable Case: 10½" high x 8¼" wide x 7¾" deep Panel-Mounting Case: 10⅜" high x 8⅝" wide x 7¾" deep. Depth behind front of panel 5¼"
Weight	15 lbs. in portable case
Chart Paper Dimensions	Calibrated width 5". Overall width 6⅜". Length 85 feet, approximately
Power Requirements	105-120 volts, 58-62 cps, single phase 55 va max. Power factor approximately 0.7
Full-span Balancing Time	Less than 1 second with full span step input
Limit of Error	1% of span, unless otherwise specified below
Deadband	½% of span
Permissible Source Resistance	See Section 1.6.1
Ambient Temperature Range	32° F to 105° F

1.6.1 Input Chassis Specifications

The following specifications pertain to the G-11A Recorder equipped with the input chassis indicated:

TYPES A1 AND A2 INPUT CHASSIS	
Input Signal Span	9 mv to 100 mv continuously variable
Permissible Source Resistance	9 mv to 20 mv — 50k ohms maximum 21 mv to 50 mv — 75k ohms maximum 51 mv to 100 mv — 100k ohms maximum
Input Resistance	Infinite at null-balance
Resistance Off Balance	Larger than 0.5 megohm off null-balance
TYPE B1 WIDE-RANGE INPUT CHASSIS	
Limit of Error	1% of span on .01-v setting, 2% of span on all other settings
Input Resistance	Infinite at null balance on the .01-v setting; 0.1 megohm on .02-, .05-, .10-, .20-, .50-, and 1.0-v settings; 1 megohms on 10-v setting; 10 megohms on 100-v setting
Permissible Source Resistance	.01 volt setting — 50k ohms maximum, all other settings — no limitation
TYPE F1 CURRENT INPUT CHASSIS	
Limit of Error	1% of span
TYPE T2 THERMOCOUPLE INPUT CHASSIS	
Ambient Temperature Range	32° F to 105° F (range of reference junction compensation)
Ambient Temperature Rate of Change	20° F per hour maximum

1.7 ACCESSORIES

The Model G-11A Recorder may be easily adapted in the field to changing recording requirements. Chart motors may be replaced or added, the mode of writing changed, and input chassis substituted. The following is a description of available accessories.

1.7.1 Chart Motors

The G-11A Recorder can be equipped with one or two chart motors. Table I lists the standard chart speeds available.

If two motors are to be used, any combination of standard motors (Group A) can be installed, but not two high-speed (Group B) motors. The combination of a standard-speed (Group A) and a high-speed motor (Group B) can be accommodated. One motor only of Group C can be mounted in the G-11A Recorder.

1.7.2 Speed Shifter

A mechanical speed shifter is available which provides two speeds. In HIGH position the speed shifter operates as a 1 : 1 gear train. In LOW position it reduces the basic chart speed by a factor of 4. Two motors with a speed shifter can provide a choice of four chart speeds.

1.7.3 Event Marker

Event marking on the right-hand margin of the chart can be accomplished by installing event marker kit #902033. This kit is available for operation at the following voltages:

6 volts a-c	6 volts d-c
12 volts a-c	12 volts d-c
110 volts a-c	28 volts d-c

Maximum repetition rate is 5 pulses per second. Stylus Assembly #316A adapts the event marker for inkless recording. See Figure 5-4, Mechanical Parts List.

1.7.4 Inkless Recording Accessories

To employ inkless recording with the G-11A Recorder, pen Type 720B must be replaced by Type 997 Stylus Assembly. Special chart paper (Type 5B) must also be used. Stylus Assembly #316A (see Section 1.7.3 above) permits use of the event marker with inkless paper.

1.7.5 Panel Mounting

Conversion Kit #901719 contains all hardware needed to convert a portable G-11A to panel mounting.

A 19-inch rack panel for a single G-11A Recorder is available separately as #960359.

Dual Panel Mounting Kit #901718 provides all required hardware plus a suitable panel for side-by-side mounting two G-11A Recorders in a 19-inch rack.

1.7.6 Range Elements for Type T2 Input Chassis

Temperature range and thermocouple type changes are accomplished on G-11A Recorders equipped with T2 Input Chassis by replacement of plugable Range Elements. A detailed list of available Range Elements is shown in Section 5, Parts List.

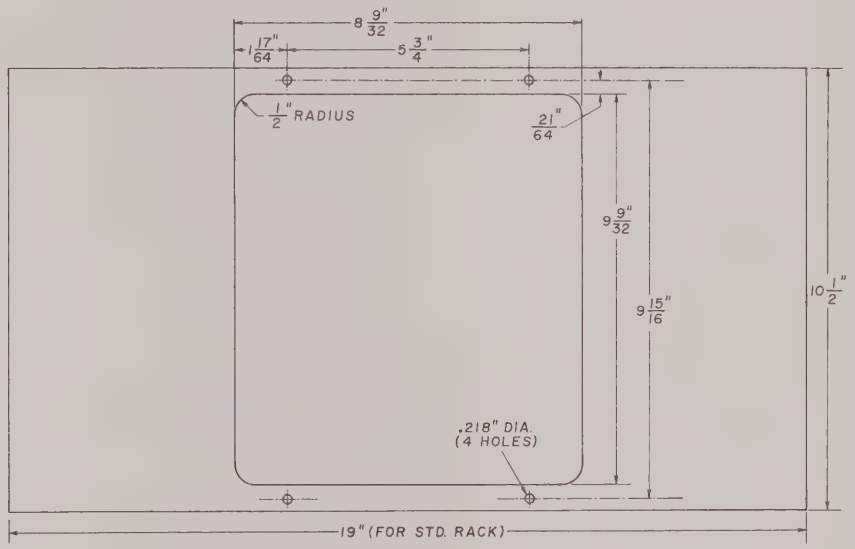


Figure 1-7: Panel Mounting Plate for a Single Recorder

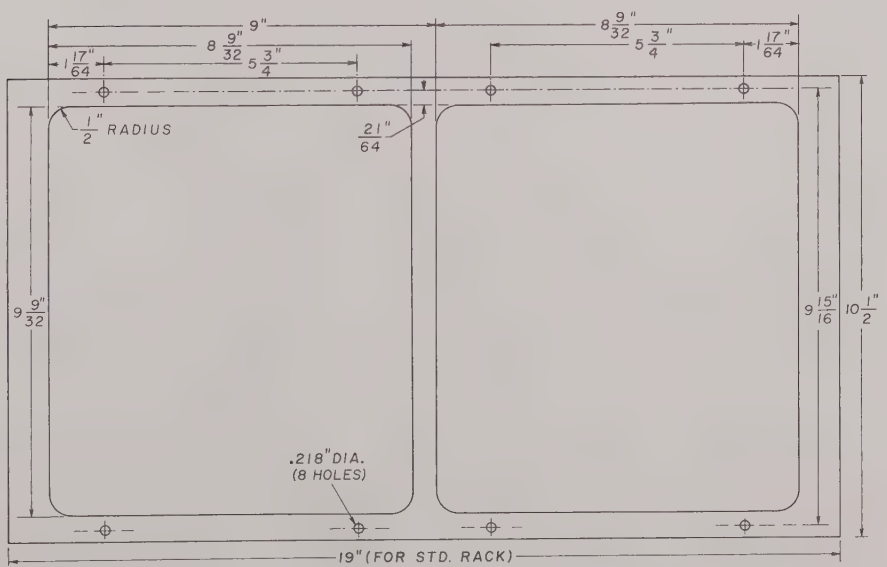


Figure 1-8: Panel Mounting for Two Recorders

TABLE I

CHART MOTOR SPEEDS

GROUP A: Standard Chart Speeds

Basic Speed (inches per hour)	Additional Speed with Shifter (inches per hour)
½	⅛
1	¼
2	½
3	¾
8	2
12	3
15	3¾
20	5
24	6
30	7½
(inches per minute)	**(inches per hour)**
1	15
2	30

GROUP B: Optional High Chart Speeds

Basic Speed (inches per minute)	Additional Speed with Shifter (inches per minute)
4	1
6	1½
8	2

GROUP C: Special High Chart Speeds

Basic Speed (inches per minute)	Additional Speed with Shifter (inches per minute)
10	2½
12	3
16	4
20	5
24	6
40	10
50	12½
60	15

theory of operation

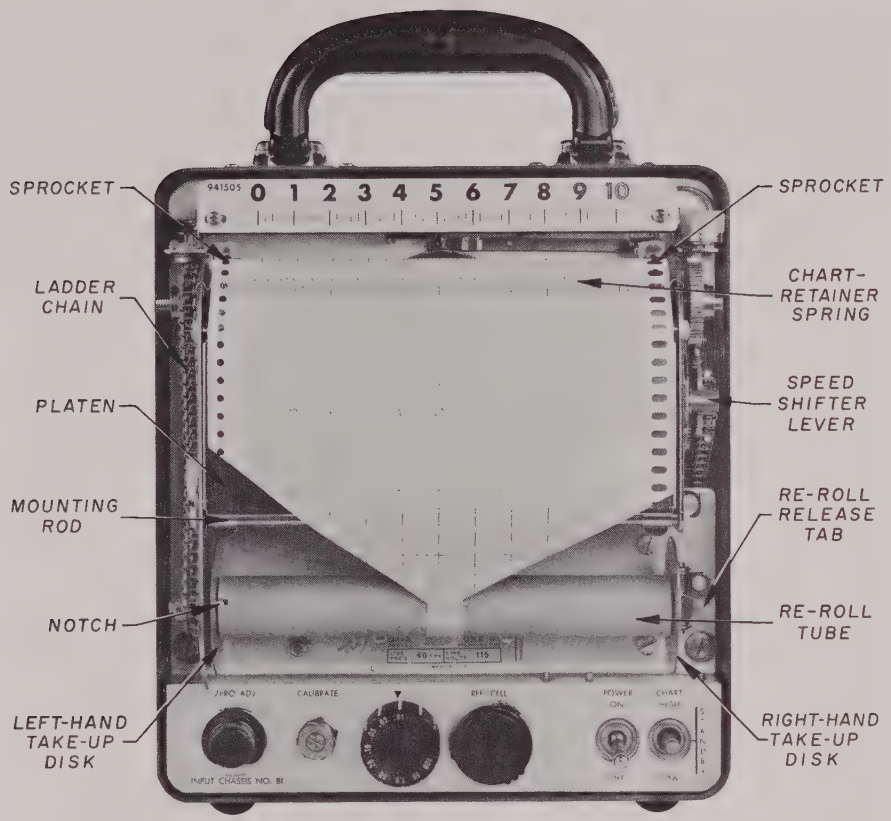


Figure 2-1: Chart Paper Installation

2.0 THEORY OF OPERATION

2.1 INTRODUCTION

When it becomes evident that equipment has sustained damage in shipping, refer to the statements opposite the inside rear cover of this manual. DO NOT attempt to operate damaged equipment.

2.2 INSTALLATION INSTRUCTIONS

2.2.1 Chart Paper Installation

(1) Remove recorder cover by depressing cover release buttons on both sides of cover and swinging cover forward and up.

(2) Remove recorder pen from pen holder.

(3) Remove platen covering chart compartment by springing platen off rods.

(4) Cut chart-paper corners to form a tapered end as shown in Figure 2-1. Save masking tape for use in step (10).

(5) With printed side of paper toward rear of instrument, insert pointed end of chart paper through the space behind chart-drive roller.

(6) Insert chart-paper roll in chart compartment and snap platen in place on mounting rods. If platen clips do not engage rods properly, bend clips slightly to adjust clip spacing.

(7) Place speed shifter lever in N (neutral) position, and grasp tapered end of chart paper and front portion of ladder chain on left-front side of recorder. Simultaneously pull chart paper forward and ladder chain down to engage sprocket teeth in paper perforations.

(8) Continue pulling chart paper forward until chart paper perforations are properly engaged with sprocket teeth. If necessary, lift paper hold-down clips to adjust chart paper.

(9) Roll chart paper forward until approximately 8 inches is exposed in front of paper hold-down clips.

NOTE

If desired, feed chart paper through the slot in bottom of front cover (rather than use the re-roll tube), insert tapered end of chart paper behind chart paper retainer spring and feed chart paper through slot.

(10) With notched end of re-roll tube toward the left, attach tapered end of chart paper using tape removed in step (4). Take care to center the chart paper on re-roll core. Wind approximately two turns of chart paper on core.

(11) Place tube on left-hand take-up disk, swing out right-hand take-up disk to right and insert re-roll tube on right-hand take-up disk. See Figure 2-1. Rotate left-hand take-up disk until projection on disk slips into notch on re-roll tube.

(12) Pull ladder chain down to check re-roll and tautness of paper. If chart paper is not centered or is loose on tube, repeat steps (9) through (12).

2.2.2 Type 720B Recorder Pen Installation

These instructions cover installation of a clean recorder pen. Instructions regarding care and cleaning of recorder pens are given in Section 4.4.4.

(1) Remove pen cap and fill pen container to about ⅛-inch from top. Replace pen cap to prevent ink from drying and clogging capillary pen tubing.

(2) Raise recorder scale and pen holder. With pointer toward front, insert one end of pen container in holder and slide other end in place.

(3) Keeping pen holder raised, gently push pen container down. Release pen holder and check pen tip as it contacts chart paper. Keep adjusting pen height until pen is perpendicular to chart at contact.

NOTE

Do not force pen tip into chart paper.

(4) Lift pen off chart paper and prime by squeezing pen cap. This should cause an ink droplet to appear at pen tip. Release recording pen.

(5) Check correlation between indications on paper and on scale. If necessary, loosen scale mounting screw and position scale as required. Tighten mounting screws.

2.2.3 Type 997 Pen Installation (Inkless Stylus)

To install the inkless stylus assembly, proceed as follows:

(1) Loosen screw on top of Type 997 stylus assembly.

(2) Insert spring clips of pen holder into clamp on stylus assembly.

(3) Position stylus assembly so that stylus is perpendicular to chart paper. Tighten screw.

(4) When the stylus assembly is properly installed it is parallel to the pen carriage rod and the stylus is vertical.

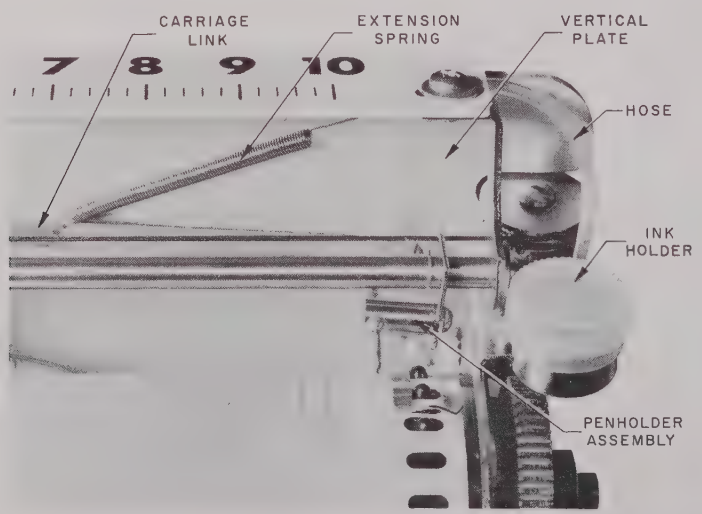


Figure 2-2: Type 434A Event Marker Pen Installation

2.2.4 Type 434A Event Marker Pen Installation

Event Marker Pen Type 434A, when ordered with the G-11A Recorder, comes installed and factory adjusted. To avoid damage in shipment, it is immobilized with a rubber band and the extension spring end is disengaged from the notch in the recorder chassis.

Refer to Figure 2-2. To prepare Event Marker Pen for operation, remove rubber band from pen holder assembly, remove tape holding end of extension spring, and insert spring end into notch on vertical chassis plate. Remove cap from ink container and fill container with ink. Replace cap and prime pen by pressing a few times on the cap with finger or thumb, until an ink droplet appears at pen tip. Priming can be achieved faster when the pen tip is lifted off paper.

NOTE

Check carefully relay coil voltage requirements before applying energizing voltage.

2.2.5 Event Marker Inkless Stylus, Type 316A

Type 316A Event Marker Stylus comes factory installed when ordered with G-11A Recorder. Instructions of Section 2.2.4 with the exception of those pertaining to ink filling and pen priming apply also to this configuration.

2.2.6 Installing G-11A Recorder in a Panel

To mount the G-11A Recorder in a rack panel, proceed as follows:

(1) On portable version of the G-11A, remove the recorder assembly from the case, as in Section 4.4.1, then remove the handle and the four feet of the case. On panel-mounting versions, remove recorder assembly from case.

(2) Install mounting brackets on recorder case, but do not tighten nuts. Screws must be inserted from inside of case. See Figure 2-3.

(3) Insert the assembly prepared in step (2) into panel, install bezel, and fasten bezel screws.

(4) Replace cover. Move case in or out of the panel until bezel touches, but does not interfere with the cover.

(5) Remove cover and tighten nuts installed in step (2).

(6) Install recorder assembly in case.

Installations of two G-11A Recorders side-by-side in a panel differs only in the hardware required.

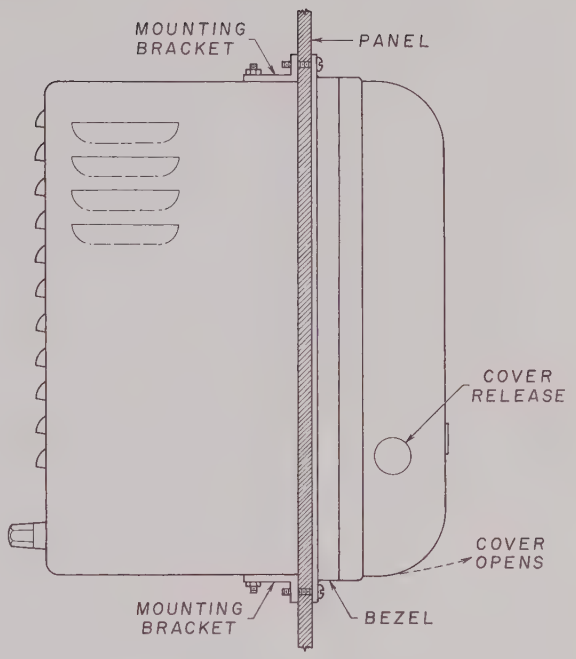


Figure 2-3: Installation of G-11A in Mounting Panel

2.3 RECORDER OPERATION

Operating instructions are given in Section 2.3.1 below followed by a description of the controls and terminals in Section 2.3.2.

2.3.1 Detailed Operating Instructions

(1) Check supply of chart paper and ink. Replenish as necessary.

(2) Connect power cord to a-c power source. Model G-11A Recorder may be operated from an inverter-type power supply. See Section 1.6 for power requirements.

WARNING

Be sure Recorder is grounded. **Model G-11A Recorders have a three-wire power cable terminating in three-prong plug. The tubular pin in this plug completes the ground connection. If this connection is broken for any reason and the recorder is not grounded, the case is placed at approximately 60 volts a-c.**

(3) Turn POWER switch ON.

(4) Connect input signal source to input terminals J101 and J102.

(5) If recorder is equipped with an event marker, connect event marker power source to terminals 1 and 2 on event marker terminal board.

NOTE

Be sure power is of proper voltage for event marker type used.

(6) If recorder is equipped with a mechanical speed shifter, select chart speed by placing speed shifter in either HIGH or LOW position.

(7) If recorder is equipped with type B1 Input Chassis, place VOLTS control on desired measurement range.

(8) Place CHART switch on HIGH or LOW positions. In recorders equipped with one motor, only the HIGH position actuates the chart motor.

(9) Place recorder pen at desired initial position using ZERO ADJust control. This control allows the recorder pen to be set anywhere on the chart and, electrically, about 20 percent beyond either end of chart calibration.

(10) Adjust controls for proper operation. In most instances such adjustment will be unnecessary although adjustment of DAMPING and GAIN controls may be required to adapt the recorder to the particular input signal amplitude and source impedance. See Sections 4.2.1 and 4.3.3.

(11) Record input signal. Actuate event marker as required.

2.3.2 Controls and Terminals

Input Terminals (J101 and J102)	Inputs for signals. Red terminal is positive (+) for left-to-right pen travel
Ground Terminals (J108)	Provides connection of external ground and of signal negative to chassis.
Switch POWER ON-OFF (S201)	Controls a-c power to recorder.
Switch CHART HIGH-STANDBY-LOW (S202)	Controls power to chart motors and to the line winding of the servo motor. Recorders equipped with one motor are always actuated on HIGH.
Speed Shifter Hi-N-Lo (optional)	Provides direct drive (Hi) and 4 to 1 speed reduction (Lo) ratio. N is neutral (disengaged).
ZERO ADJ.	Allows continuous adjustment of pen position to any point on chart, and electrically about 20% beyond either end of chart calibration.
CALIBRATE	Acts as a fine span adjustment and allows compensation of mercury cell discharge.
SPAN	Permits setting the recorder span at any required value within the range of the input chassis.
DAMPING	Permits adjustment of recorder for proper dynamic response at different signal magnitudes, sources resistances, and amplifier gain settings.
GAIN	Provides gain adjustment to compensate for tube aging and amplitude of signals.
VOLTS (B1 Input Chassis only)	Permits setting of input attenuator to desired full-span value.
RANGE ELEMENT (T2 Input Chassis only)	Permits selections and change of thermocouple type and temperature range.

2.3.3 Operating Remarks and Recommendations

The presence of voltages of power-line frequency at the recorder input may result in impaired recorder performance. The following describes a few methods for reducing the effects of a-c voltage at the input.

A-c voltages may be picked up by wires connecting the input signal source to the recorder, especially if the signal source has high internal impedance. These undesirable a-c voltages may be eliminated by using shielded wires to connect the input signal source to the recorder. If shielded wires are used, the shield should be grounded only at the ground terminal of recorder. Grounding both ends of the shield can produce ground loops. Most low-impedance sources will not require shielding. Simple twisted-pair leads will usually be satisfactory.

The input circuit of the recorder incorporates an RC filter to minimize the line frequency components. See Figures 3-2 and 3-3. If the a-c component appearing in the input circuit is large, some of it may pass the filter and appear as signal voltage, thus degrading recorder performance.

Because the recorder is usually powered from a single-phase grounded line, recorder performance may be impaired when balanced input signal voltages are applied. Under these conditions either change the ground point of the signal source or isolate the recorder from power-line ground by an electrostatically shielded isolation transformer.

Large a-c voltages appearing between signal negative (terminal J102) and chassis ground (terminal J108) may interfere with proper recorder operation. This situation can be remedied by connecting terminal J102 and chassis ground (J108). When this solution cannot be employed, connect a capacitor (10 μf or larger) between signal negative and chassis ground.

Model G-11A Recorder may be operated with a steady d-c potential of $\pm$200 volts maximum between chassis ground and the input signal. Under this condition, especially when the recorder is operated in extremely humid environments, a small zero position offset of recorder pen may occur. This is caused by minute leakage currents amplified by the high-gain servo amplifier. If the offset is constant it can be eliminated by adjusting the ZERO ADJust control.

The G-11A Recorder may be used with signal sources having resistances greater than those specified in Section 1.6.1. Operation under such conditions may cause some deterioration in recorder performance. For example, recorders equipped with type A1 and A2 Input Chassis and set to 100 millivolt span may have a dead band approaching 1% with .5 megohm source resistance.

Sometimes it is possible to extend the measurement span of the millivolt chassis by utilizing external attenuators. Under such conditions, loading of the signal source and total source resistance as seen by the recorder should be taken into consideration. Type B1 Input Chassis has a built-in attenuator, extending the measurement range to 100 volts. Specifications of the G-11A Recorder equipped with Type B1 Input Chassis are given in Section 1.6.1.

operation

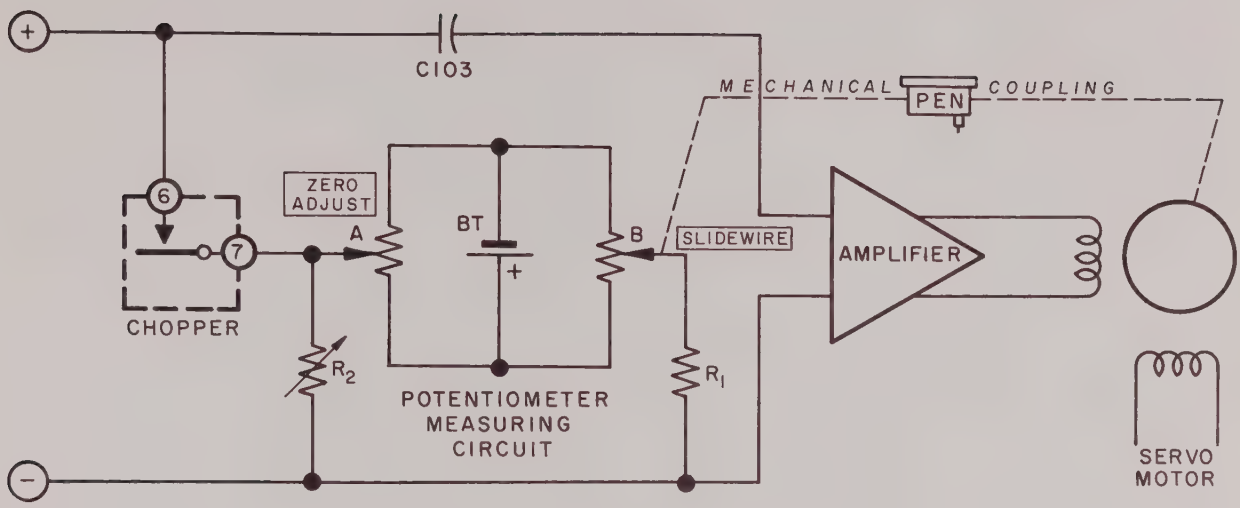


Figure 3-1: Functional Diagram, Model G-11A Recorder

3.0 OPERATION

3.1 INTRODUCTION

The Model G-11A Recorder is available with a variety of different input chassis. Because the circuits used in the various input chassis differ, the detailed description of each type is given in separate sections. However, the discussion of the potentiometer measuring circuit, chopper, servo amplifier, balancing system, and chart drive applies regardless of the input chassis used.

3.2 BASIC DESCRIPTION OF OPERATION

The basic potentiometer measuring circuit of the G-11A is shown in Figure 3-1. This circuit consists of a stable reference voltage source, paralleled by two adjustable voltage divider potentiometers. The voltage between terminals A and B, called the measuring voltage, is added in opposition to the input signal voltage. When the measuring voltage and the signal voltage are equal and opposite, the circuit is in null balance. When one is larger than the other, an a-c signal appears at the input to the amplifier, thus energizing the servo motor and repositioning the slidewire arm until null balance is achieved. The recorder pen is connected to the slidewire arm by a drive cable. Pen position on the chart is therefore determined by slidewire arm position, and is proportional to the input voltage. The ZERO ADJ control is used to set the zero-signal pen position anywhere across the width of chart, and electrically about 20 percent beyond either end of chart calibration.

Note that at null balance the circuit does not load the input source as no current flows through the input terminals. Thus the input resistance of the recorder at null balance approaches infinity. Absence of current through the source virtually eliminates measurement errors caused by voltage drops across internal source resistance and resistance of connecting leads.

3.3 TYPES A1 AND A2 MILLIVOLT INPUT CHASSIS

The schematic of Type A1 Input Chassis is shown in Figure 3-2. An RC filter in the input of recorder, R110-C102-R102, minimizes the influence of stray voltages at power line frequency. C101 is a bypass to ground for these stray voltages. See Section 2.3.3 for discussion of this problem.

The measuring circuit consists of R105 - ZERO ADJ; R106 - CALIBRATE; R107, BT101 - REF CELL; and R216 - SLIDEWIRE. A voltage divider, consisting of R108, R101, R109, and R104 allows the measuring circuit to operate at relatively high levels (approximately 1 volt) as compared to the recorder span of 9 to 100 millivolts. This arrangement attenuates electrical noises generated at the slidewire movable contact.

The R108-R101 part of the voltage divider together with C105, operates as an adjustable RC network, forming a DAMPING control. Note that the slider movement of R101 does not change the d-c voltage in the voltage divider string and so does not affect the null balance position of the slider on R216.

To set the recorder for any span between 9 and 100 millivolts, the R109-R104 portion of the voltage

divider is adjustable. Adjusting R109, the SPAN control, changes the voltage division ratio causing a change in the span of signal voltage which can be balanced out by the same travel of the movable contact of slidewire R216.

Refer to Figure 3-1. It may be seen that the error signal can be of either polarity depending on whether the instantaneous value of measuring voltage is larger or smaller than the value of signal voltage. When applied to the chopper, the result is a square wave of polarity corresponding to that of the error signal. Section 3.3.1 describes in detail the chopper operation. Other functional assemblies such as the amplifier, servo motor, balancing system, etc., are described separately in Sections 3.7 through 3.10.

Type A2 Input Chassis contains an electronic reference voltage supply in place of the mercury cell used in the Type A1. In most other details both chassis are similar. This supply provides a continuous and steady reference voltage source which does not require periodic checking and replacement. The schematic of Type A2 Input Chassis is given in Figure 3-3; schematic of the electronic reference supply is shown in Figure 3-5.

3.3.1 Chopper Circuit

The chopper converts the d-c error voltage to a modified square wave voltage. This is necessary so that the error voltage may be amplified with the required stability.

Refer to Figure 3-2. The chopper, CH101, which operates at power line frequency, has a 50 percent duty cycle; that is, contacts 6 and 7 are open (or closed) about 50 percent of the time. When chopper contacts 6 and 7 are open, capacitor C103 charges to a value equal to the signal voltage, and the voltage applied to the amplifier is zero. When contacts 6 and 7 are closed, the part of measuring voltage which appears across resistors R104 and R109 is compared

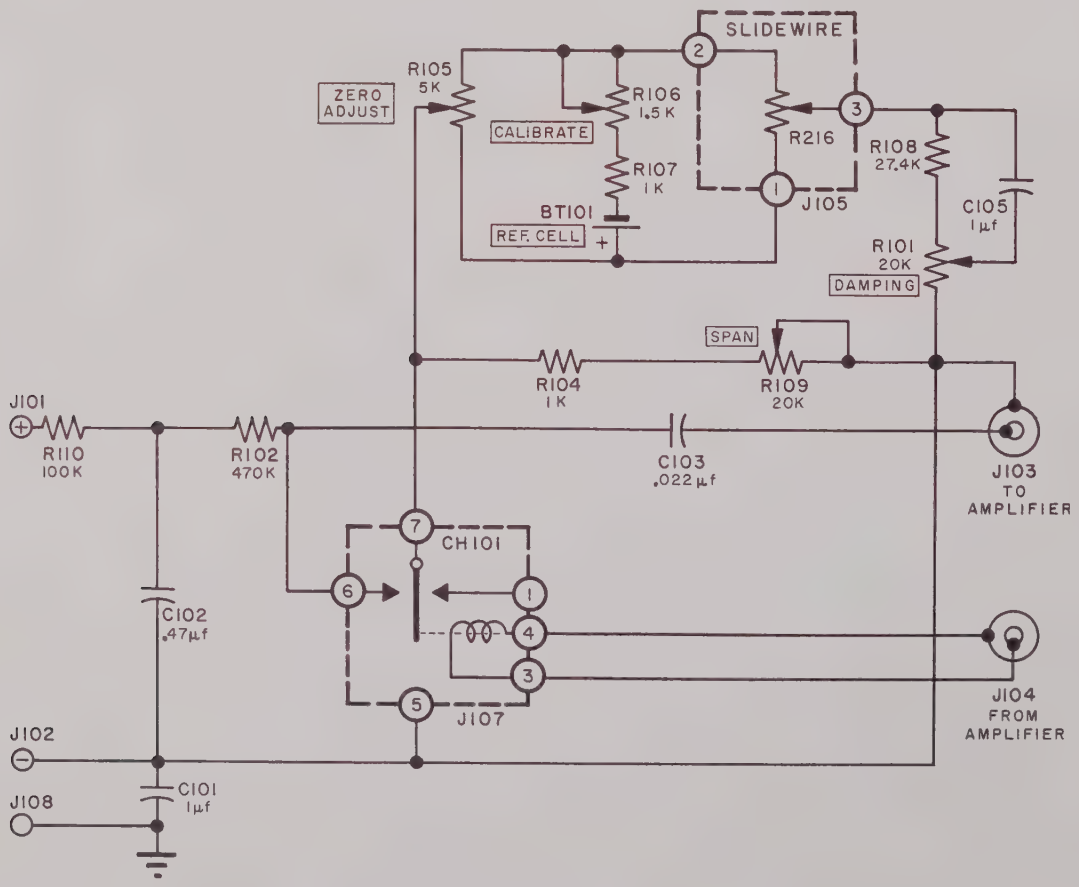


Figure 3-2: Type A1 Input Chassis, Schematic Diagram

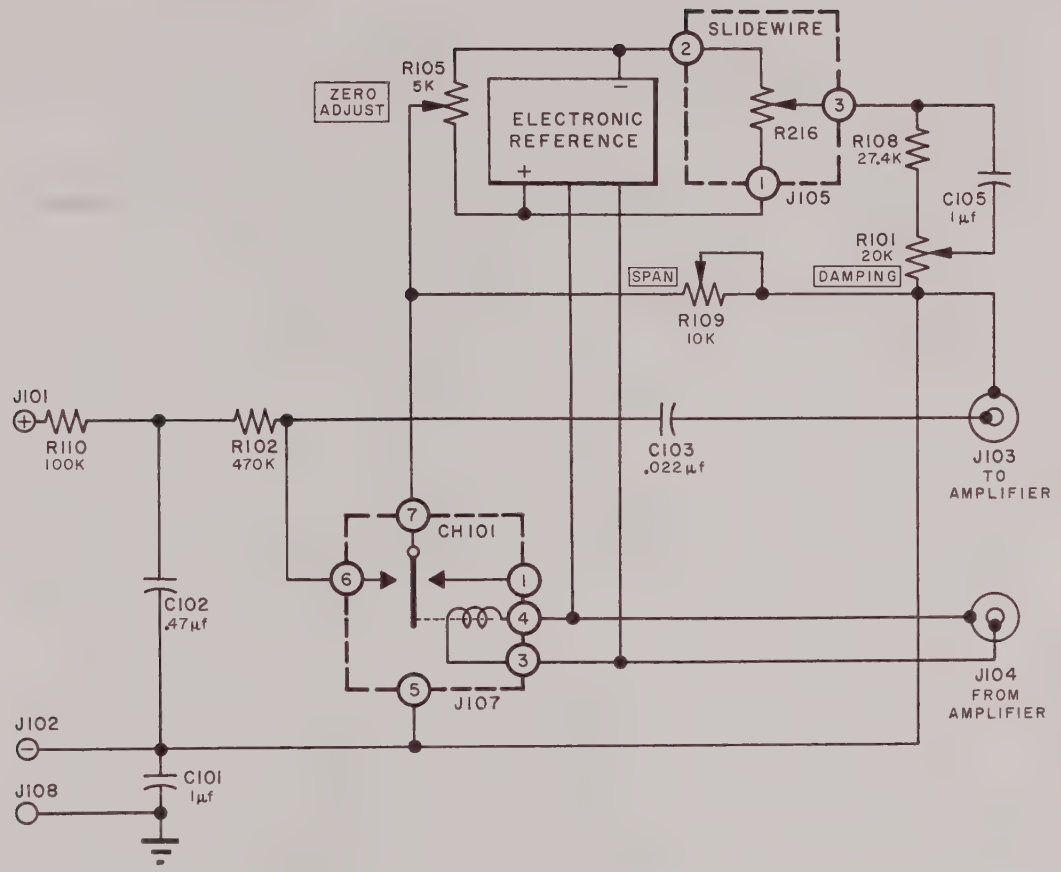


Figure 3-3: Type A2 Input Chassis, Schematic Diagram

to the signal voltage across C103. If both voltages are equal, the system is at null balance and the voltage applied to the amplifier is zero. If the voltage across R104-R109 differs from the signal voltage, the difference voltage will be applied to the amplifier as C103 either charges or discharges.

If the d-c error voltage is positive with respect to terminal J102, the a-c output from the chopper, the *balancing voltage* will be as shown in A of Figure 3-6. If the error voltage is negative, the balancing voltage will be as shown in B of Figure 3-6. Balancing voltage for zero error is shown in C of Figure 3-6.

Thus, the balancing voltage has a peak-to-peak amplitude determined by the amplitude of the error voltage, and a phase determined by the polarity of the error signal. The phase of the balancing voltage determines direction of servo motor rotation as explained in Section 3.8.1.

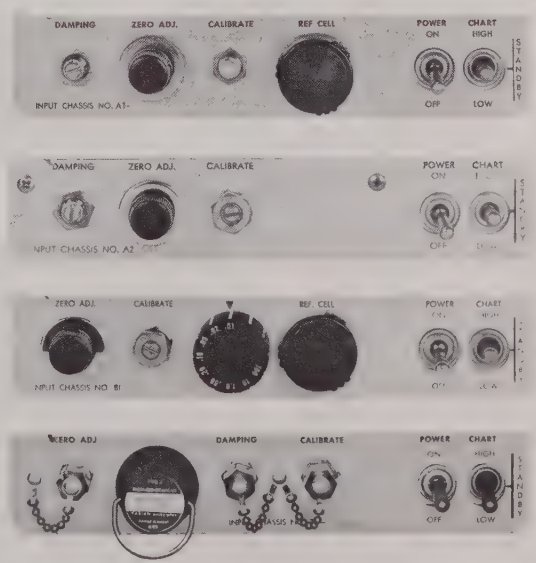


Figure 3-4: Types Input Chassis, Front Operating Views

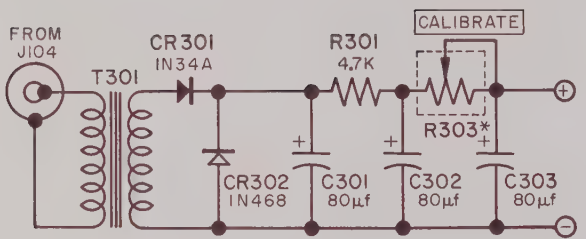


Figure 3-5: Schematic, Electronic Reference Voltage

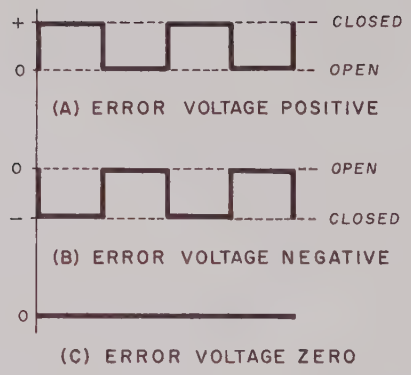


Figure 3-6: Chopper Operation

3.4 TYPE B1 WIDE-RANGE INPUT CHASSIS

Type B1 Input Chassis, Figure 3-7, is basically a 10-millivolt Type A1 Input Chassis with an adjustable attenuator in the input. This attenuator is arranged so that the input voltage to the measuring circuit is 10 millivolts at full-span regardless of the attenuator settings. In all positions other than the 10-millivolt position, a shunt attenuating network is connected to the input. For example, in the 50-millivolt position, a 100-K shunt resistance is placed across the input terminals, consisting of 80-K and 20-K resistances. Thus, a 50-millivolt full-span input signal across a resistance of 100K will produce a current of 0.5 μa. This 0.5 μa current through the 20K resistance will produce a voltage drop of 10 millivolts. In the 10-millivolt position, the attenuator is switched out and the recorder is reverted to true potentiometric operation. In this position the shunt attenuator does not load the signal source.

In other aspects, B1 Chassis is similar to A1 Chassis.

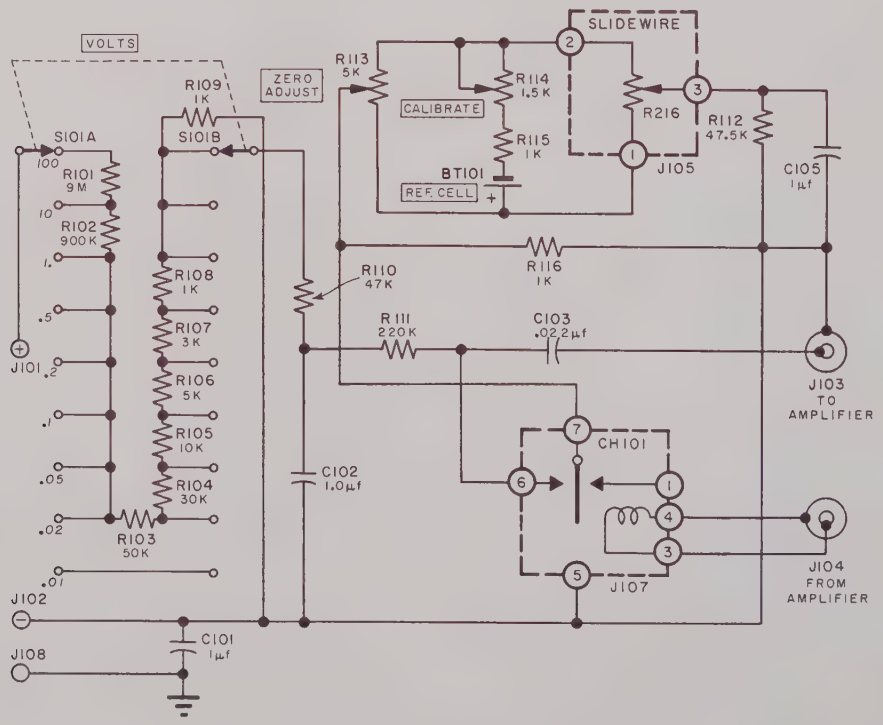


Figure 3-7: Type B1 Input Chassis, Schematic Diagram

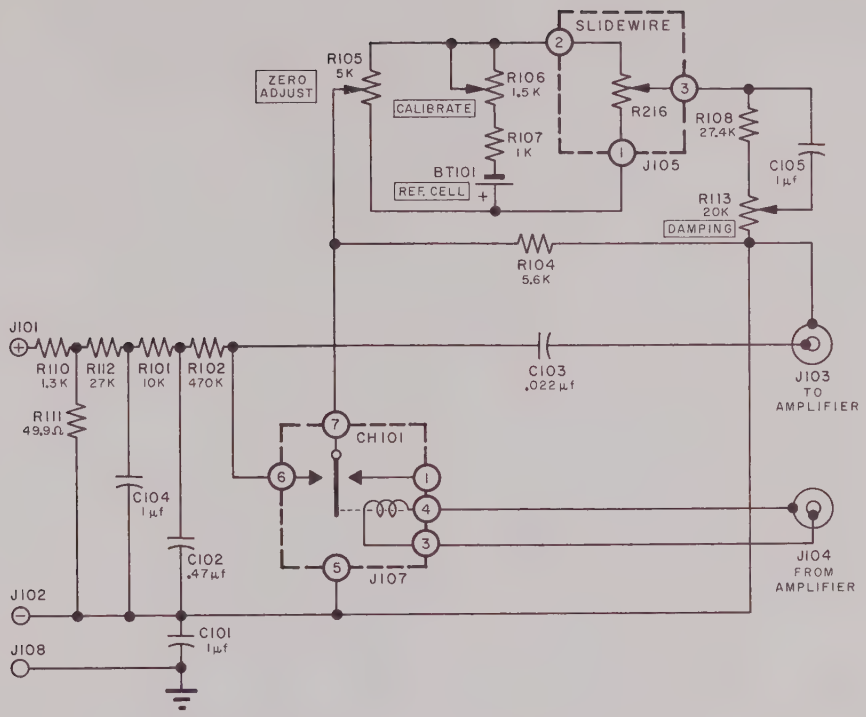


Figure 3-8: Type F1 Input Chassis, Schematic Diagram

3.5 TYPE F1 CURRENT INPUT CHASSIS

Type F1 Input Chassis is designed for use with equipment delivering 1 ma full-span current into 1350-ohm load. The schematic for the Type F1 Chassis is shown in Figure 3-8.

Because indicating meters serve as low-pass filters, complete filtering of output current is not required in equipment designed to use these indicating devices. However, hum which is very often present in the output current of such equipment, can product serious difficulties in a 60-cps servo system. A 60-cps RC filtering network (R112-C104) has therefore been added. Resistors R110 and R111, acting as a voltage divider, form the input circuit. Current through this divider is proportional to voltage developed across R111. From this point on the circuit is similar to that of the A1 Input Chassis.

3.6 TYPE T2 THERMOCOUPLE INPUT CHASSIS

Type T2 Input Chassis is designed to adapt the Model G-11A Recorder to temperature recording from thermocouple inputs. As in other G-11A input chassis, the basic measuring circuit is a null-seeking potentiometer. In the T2 Input Chassis the thermocouple reference junction is at the recorder, thermocouple wires being connected directly to the recorder input terminals. The T2 Input Chassis incorporates a temperature-responsive element in the measuring circuit which compensates for changes in ambient temperature at the thermocouple reference junction.

See Figure 3-9, the T2 Input Chassis Schematic. R104 is a temperature-sensitive resistor which is physically and thermally located at the thermocouple reference junction. The change in resistance of this device with ambient temperature causes a change in voltage, which is made to cancel the change in thermocouple voltage output caused by variation of reference junction temperature. This allows the recorder to accurately measure temperature without regard to temperature of the reference junction.

Resistors R401 and R402 are used to adjust current through resistor R104. They are designed to make the rate of change of voltage with respect to temperature change ($\Delta v/\Delta t$) match the characteristic EMF of the thermocouple type used. R401, R402, R403 and R404 are contained in the plug-in Range Element which is easily replaceable.

An electronic voltage supply, Figure 3-5, is the source of reference voltage. This voltage is applied to R216, the servo-driven slidewire in the recorder. R103A and R103B operate differentially to shift the

voltage on slidewire R216 and serve as ZERO ADJ control. Resistors R106 and R404, and the combination of R101 and R102, serve as a voltage divider to attenuate the output of the slidewire R216, and thereby match the slidewire output to the desired temperature span.

The span may be changed by changing resistor R404. Resistor R403 adjusts the current drain from the electronic reference supply to a constant value, compensating for changes caused by substituting R401, R402, and R404.

Thus reference junction compensation determined by resistors R401 and R402, temperature span set by R404, current drain from the reference supply made constant by R403, and the thermocouple-type/temperature-range can be changed by changing the Range Element. Once R103, ZERO ADJ, and R303, CALIBRATE, controls are properly set, Range Elements may be substituted without readjustment of these controls. Installation of suitable chart paper and scale completes the temperature-range/thermocouple-type change-over.

3.7 SERVO AMPLIFIER

The servo amplifier, schematically shown in Figure 3-10, has five amplifying stages consisting of dual triodes V201 and V202, and output stage V203. As the first stage operates at extremely low signal levels tube V201 is selected for low hum. The output stage uses a beam power tube V203 which drives the servo motor through impedance matching auto-transformer T201. T201 and C212 in parallel, tune the plate circuit of V203 to 60 cycles, thus providing selective gain at this frequency. Capacitors C204 and C208 provide required phase shift through the amplifier.

Note that in A1 or A2 Chassis tube V202 depends on the SPAN control setting as shown in Table III. Although data in the table is not critical, for best operation of the G-11A Recorder, V202 should be changed as indicated when the span of measurement is changed. See Section 4.3.3 for recorder span adjustment.

3.8 BALANCING SYSTEM

The balancing system, consisting of servo motor, mechanical coupling, and damping system, positions the movable contact of slidewire R216 and restores null balance.

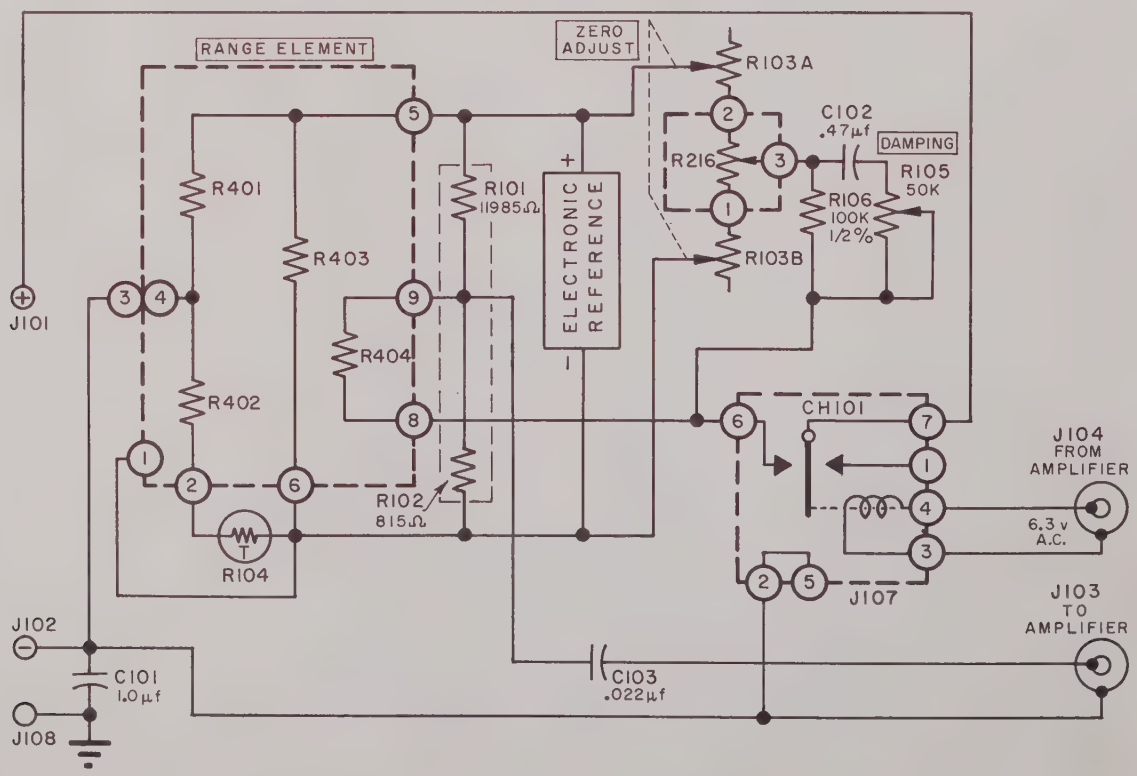
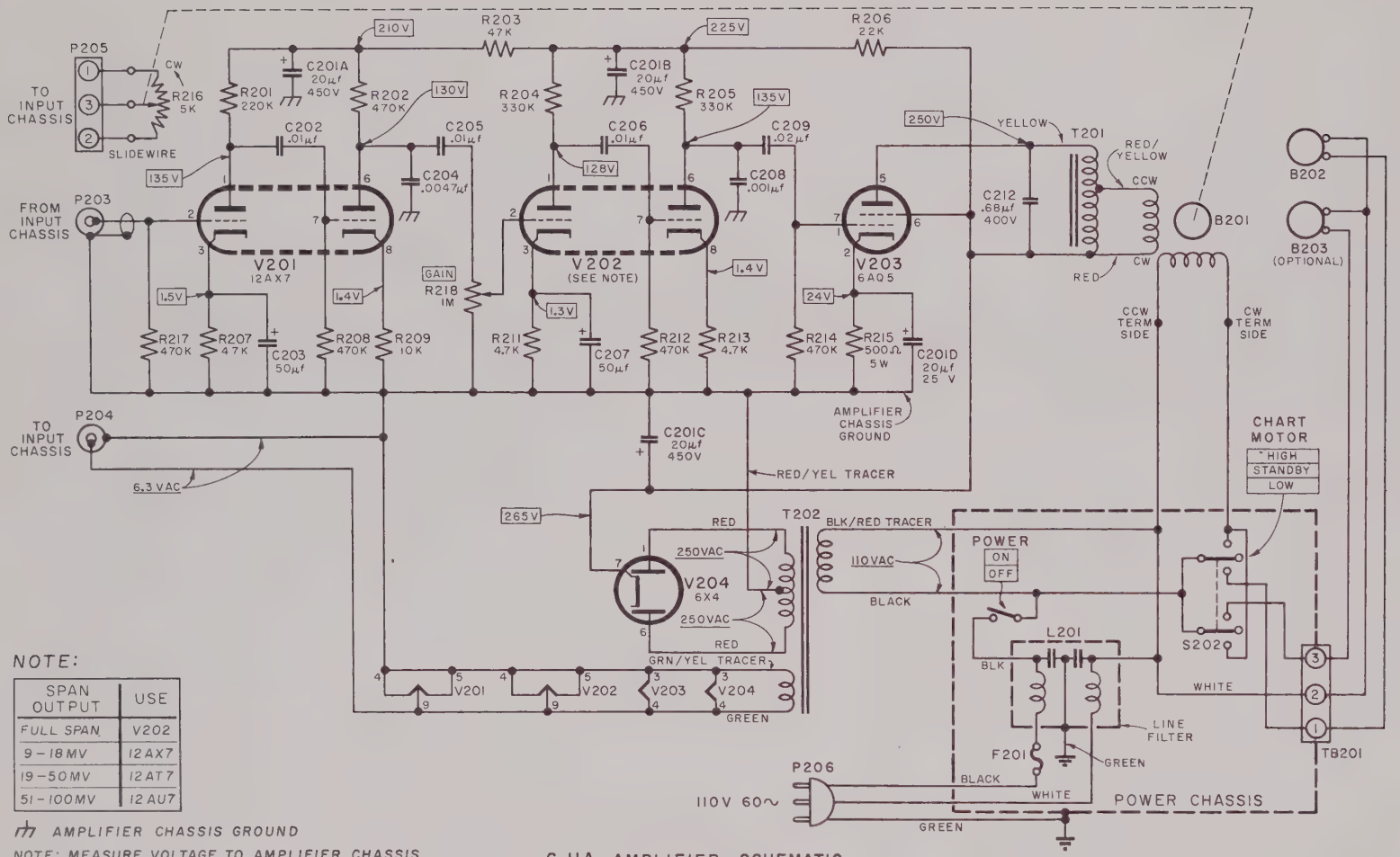


Figure 3-9: Type T2 Input Chassis, Schematic Diagram



NOTE:

SPAN OUTPUT	USE
FULL SPAN	V202
9 – 18 MV	12AX7
19 – 50 MV	12AT7
51 – 100 MV	12AU7

⏚ AMPLIFIER CHASSIS GROUND

NOTE: MEASURE VOLTAGE TO AMPLIFIER CHASSIS GROUND WITH 20,000 Ω/VOLT VOLTMETER; MEASURE BIAS WITH VTVM.

G-11A AMPLIFIER SCHEMATIC, SERIAL NUMBER 2851 AND ABOVE

Figure 3-10: Schematic, G-11A Servo Amplifier and Power Supply

3.8.1 Servo Motor

The servo motor is a reversible two-phase induction motor. Of the two windings used, one, the reference or line winding, is connected to the a-c power line. The other, the control winding, is excited by the servo amplifier. When a voltage phase difference of about 35 degrees exists between the line winding and control winding voltages, the servo motor delivers maximum torque in a direction determined by phase lead or lag. The servo motor responds only to signals of power line frequency and in a definite phase relation to the power line voltage. Phase requirements are satisfied by the excitation voltage, which, as described in Section 3.2, is derived from the error signal chopped at the line frequency. The servo amplifier, described in Section 3.7, provides proper voltage phasing and selective amplification at 60 cps. Voltages of other frequencies or phases, when present in the amplifier, are dissipated in the motor control winding as heat.

3.8.2 Damping System

The damping system counteracts the effects of inertia and thus prevents the recorder from presenting a false recording of the phenomenon being investigated. See Figure 3-2. The damping system consists of an RC network in the input chassis, R101, R104, R108, R109, and C105.

When a change in the signal voltage occurs, the damping voltage causes the system to accelerate very rapidly (about 0.1 second is required when a full-span step-function voltage is applied to the recorder) by increasing the *apparent* unbalance of the measuring circuit. Conversely when the input voltage decreases, the damping voltage causes the system to decelerate very rapidly (about 0.05 second with the reduction of the full-span step-function voltage to zero) by producing an *apparent* null balance condition in advance of the actual null. At null balance, the damping voltage becomes zero, because the rate of change of the corresponding signal voltage is also zero.

3.8.3 Mechanical Coupling Assembly

The mechanical coupling assembly, illustrated in Figure 3-11, links the servo motor, the slidewire, and the recorder pen by a drive cable through a system of sheaves and idler pulleys. The drive cable, which is attached securely to the sheaves and the pen carriage, is driven from the servo motor sheave. Because the servo motor is connected to its sheave through a cork-disk clutch, the motor shaft will slip when the pen reaches maximum deflection and the servo motor continues operation. In this way, the system is protected from damage. The spring at the top of the servo motor adjusts the pressure on the cork-disk clutch. The long spring on the pen carriage maintains the proper drive cable tension.

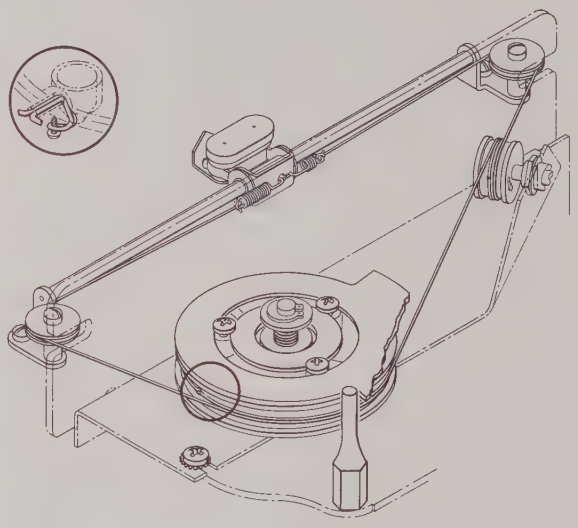


Figure 3-11: Mechanical Coupling Assembly

3.9 POWER SUPPLY AND POWER CHASSIS

The power supply of G-11A Recorder, shown in Figure 3-10, consists of a transformer T202 followed by full wave rectifier V204. A 6.3-volt winding supplies voltage for filaments and for chopper operation.

The power chassis is located next to the input chassis. In addition to the POWER and CHART switches, it contains a 1-amp fuse and a line filter. The line filter is designed to prevent line transients and other disturbances, present in the power line, from affecting recorder performance.

3.10 CHART DRIVE SYSTEM

The chart drive system provides uniform motion of chart paper with respect to the recording pen. Both the chart transport and the chart take-up are driven from the same motor. An optional speed shifter assembly provides chart speeds in 1 : 1 and 1 : 4 ratios. A typical chart motor assembly is shown in Figure 3-12. High-speed chart motors (Table I, Group 2) are two-phase and require installation of phase shifting resistors and capacitors. Figure 3-13 shows a schematic of such an arrangement and Figure 3-14 illustrates the position of these components in the recorder assembly.

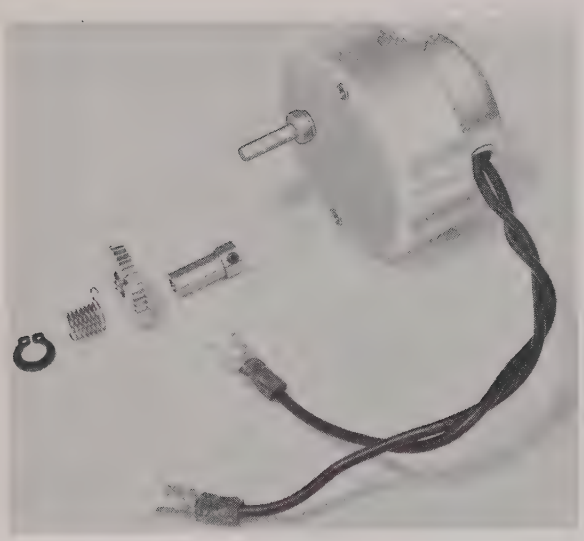


Figure 3-12: Chart-Motor Assembly

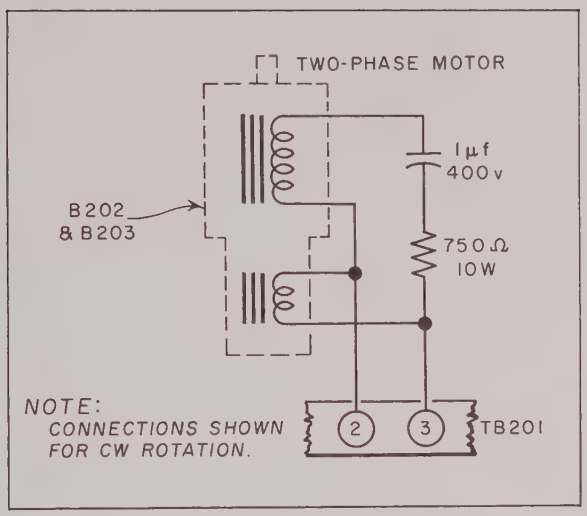


Figure 3-13: Schematic, Chart Motor

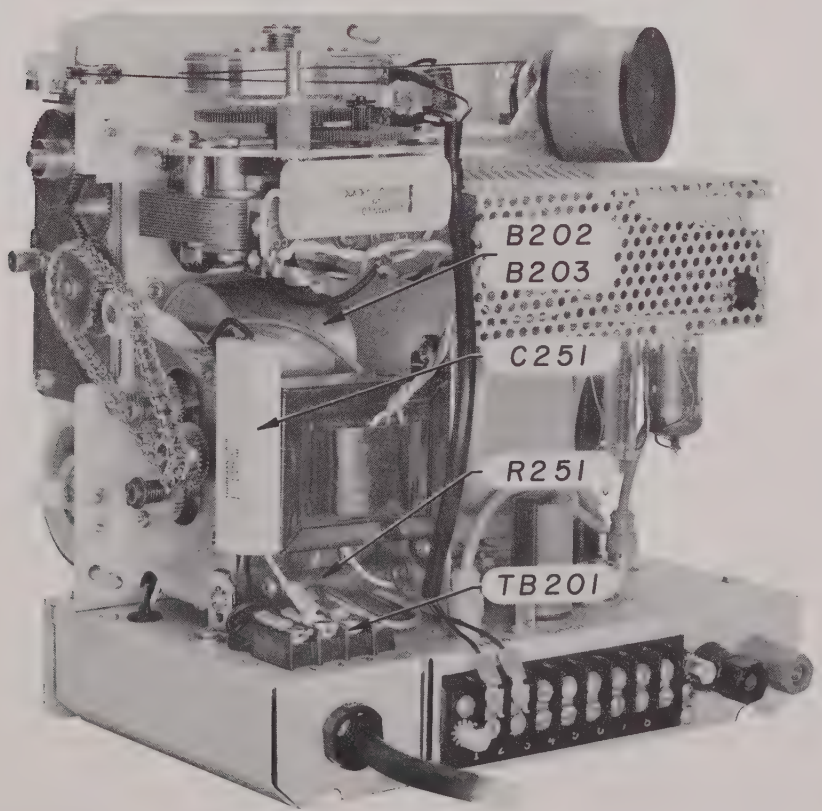


Figure 3-14: High-Speed Chart-Motor Assembly

maintenance

4.0 MAINTENANCE

4.1 GENERAL

Before attempting service, adjustment, and maintenance of *new equipment*, read the warranty statement opposite the inside rear cover of this manual.

4.2 PERFORMANCE CHECKS

Performance of the recorder may be verified by the following procedures:

4.2.1 Damping Check

(1) Check for proper recorder settings, such as span, VOLTS, range element selection, etc. Verify signal source impedance against impedances specified (see Section 1.6.1).

(2) Connect signal source to recorder input terminals. Connect power cord to suitable a-c power source.

(3) Turn power switch ON. Allow a few minutes for warm-up. Adjust chart speed controls for most suitable chart speed.

NOTE

A large selection of chart speeds is offered as shown in Table I. Extremely slow or fast chart-speeds may not be convenient for checking performance. Select the most suitable speed available in your recorder.

(4) Rotate ZERO ADJ control rapidly, first in one direction, then in the other, and observe generated traces. Compare with traces in Figure 4-1. Trace A shows an overdamped condition, trace B shows critical damping while trace C indicates overdamping.

(5) Rotate DAMPING control until recorder response approximates that of B. To correct overdamped condition, rotate control counterclockwise; to correct underdamped condition, rotate clockwise.

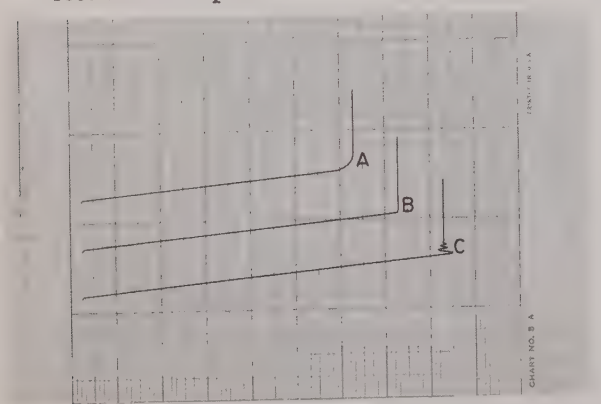


Figure 4-1: Damping Check

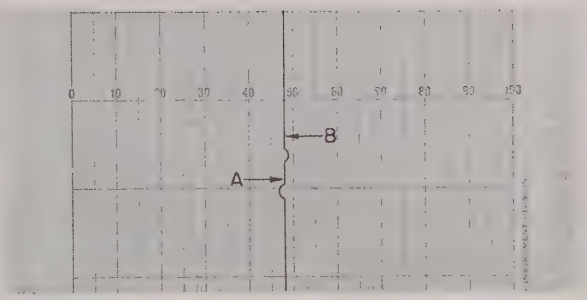


Figure 4-2: Dead Band Check

4.2.2 Dead Band Check

(1) Remove recorder assembly from case as in Section 4.4.1, observing warning note, and connect power cord to suitable a-c power source.

(2) Short-circuit input terminals.

(3) Turn POWER switch ON, and adjust chart-speed controls for desired chart speed.

(4) Position recording pen in center of chart paper using ZERO ADJ control.

(5) Rotate servo motor sheave so that recorder pen moves off balance about 2 percent of span. Slowly release sheave and note point on chart where recording pen comes to rest. This procedure is illustrated in Figure 4-2, Point A.

(6) Rotate servo motor sheave so that recorder pen moves about 2 percent in the other direction. Slowly release sheave and note new balance position. See Figure 4-2, point B.

(7) The displacement between points A and B noted in steps (5) and (6) should not exceed 1/2 of one percent of recorder span. This is the dead band as defined in Section 1.5.

(8) Disconnect power cord from a-c source and replace recorder assembly in case.

4.2.3 Chopper Check

The chopper used in G-11A Recorders operates on 6.3 volts, 60 cps. To test the chopper, proceed as follows:

(1) Remove recorder assembly from case as in Section 4.4.1, observing warning note, and connect power cord to a-c power source.

(2) Short-circuit input terminals.

(3) Turn POWER switch ON, and adjust chart-speed controls for convenient chart speed.

(4) Rotate ZERO ADJ control placing recording pen on extreme right marking of chart paper.

(5) Place CHART switch in STANDBY position and rotate ZERO ADJ fully counterclockwise.

(6) Connect chopper pins 6 and 7 to vertical input of oscilloscope. By removing the chopper from the input chassis, and connecting 3-inch lengths of #24 bus wire to pin 6 and to pin 7 by wrapping one end of each wire around one pin and carefully replacing the chopper in its socket. Make sure that the exposed wires do not touch each other or the chassis. Connect oscilloscope leads to exposed bus wire. Adjust oscilloscope controls for display of two or three cycles of the chopper output (balancing signal). As the chopper operates on a 50 percent duty cycle, the waveform on the scope should be a modified symmetrical square wave, as in A of Figure 4-3.

(7) If the scope trace shows a non-symmetrical waveform such as B or a noisy waveform such as C or D in Figure 4-3, the chopper should be replaced. Replace with Varian Part No. 901335. Secure with chopper clamp.

(8) Disconnect power cord from a-c source and replace recorder assembly in case.

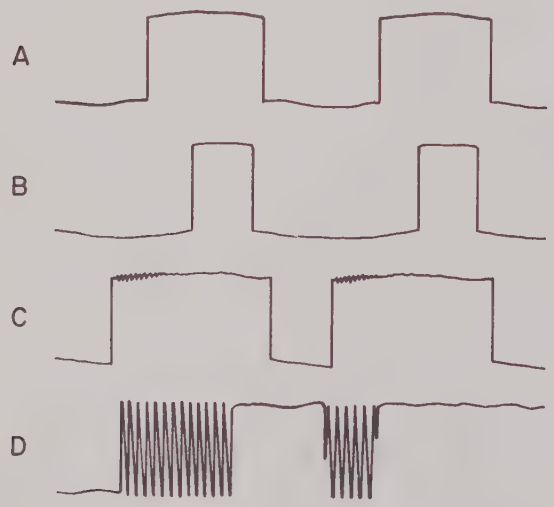


Figure 4-3: Chopper Waveforms

4.2.4 Pen Travel Check

(1) Connect power cord to suitable a-c power source and short circuit input terminals.

(2) Turn POWER switch ON, and adjust chart speed controls for highest chart speed.

(3) Abruptly rotate ZERO ADJ control to extreme clockwise position, noting velocity of pen travel.

(4) Abruptly rotate ZERO ADJ control to extreme counterclockwise position, noting velocity of pen travel. Pen should move smoothly with constant velocity in either direction across the paper.

(5) If pen does not move smoothly, consult Sections 4.4.3 and 4.4.4.

Model AG-1 Recorder Analyzer is suggested for the performance of the G-11A Recorder. Refer to the section called "Checking the Recorder for Noise" in the AG-1 Instruction Manual. See Figure 4-4 for the following indications:

(1) Traces obtained from binding in mechanical system usually caused by accumulation of dust on pen-carriage rod.

(2) Effects of *noisy* slidewire potentiometer.

(3) Changes in CURVE RATE (RC time constant).

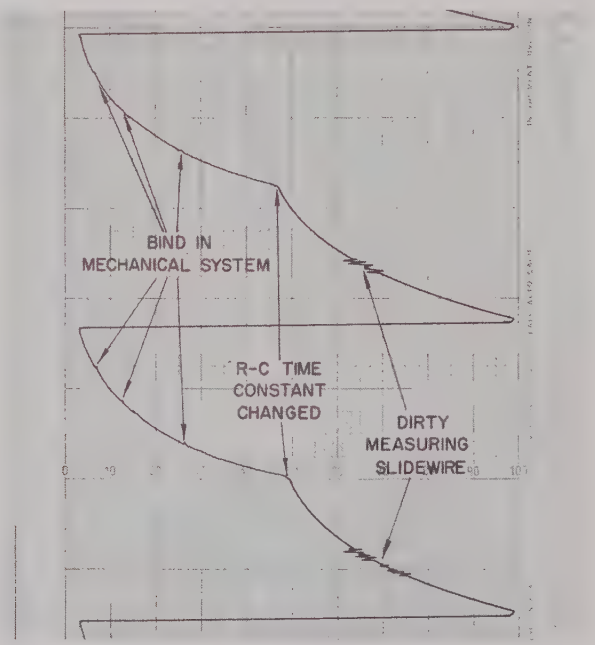


Figure 4-4: Resistance-Capacitance Discharge Curves

If the Model AG-1 Recorder Analyzer is not available, a circuit can easily be constructed to provide a capacitance-resistance discharge curve. See Figure 4-5. All components are non-critical.

(1) Voltage source is a 1.55-volt cell or spare mercury reference cell.

(2) With contactor deleted, wires may be touched together to charge capacitor.

(3) The 1K potentiometer adjusts charge level on full scale deflection.

(4) Adjust chart speed and RC time constant of discharge to obtain a trace slope of approximately 30 to 45 degrees across paper width.
(5) Smooth trace will indicate proper recorder performance.

4.2.5 Troubleshooting

Following is a list of symptoms and probable causes of recorder malfunction. Note that Figure 3-10, Amplifier Schematic, contains voltage data helpful in recorder troubleshooting and repair.

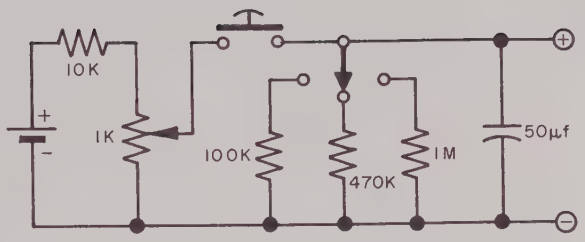


Figure 4-5: Capacitor Discharge Generator

TABLE II
TROUBLESHOOTING CHART

SYMPTOM	POSSIBLE CAUSE
Recorder fails to operate	Power cord not connected. Fuse F201 open.
Chart paper does not advance	Speed shifter in N (neutral) position. Fuse F201 open.
Chart paper binds; take-up unbalanced	Paper catches on chart sprockets. Takeup improperly adjusted.
Intermittent chart paper advance	Takeup chain loose. Drive chain loose.
Pen moves to extreme limit of travel; servo motor continues to operate	Low reference cell voltage. Chopper defective. Input circuit open.
Same as above after mercury cell replacement	Reference cell inserted with reversed polarity.
Instrument cannot be adjusted with CALIBRATE control	Low reference cell voltage.
Large dead band, sluggish operation	Low amplifier gain. Stray a-c pickup. Excessive source resistance. Low line voltage. Chopper defective. Bind in mechanical system. Excessive drive cable tension.
Non-uniform pen velocity	Bind in mechanical system (pen carriage binding on pen rod). Excessive drive cable slack. Chopper defective.
Pen "hunts" at any position of DAMPING control	Excessive amplifier gain.
Repeated pen "jitter" at same point on chart	Dirty or worn slidewire potentiometer.
Intermittent pen oscillation at various points on chart	V201 defective (microphonic). Line transients enter recorder. Loose connection of signal cable.
Zero-voltage point drifts with line voltage change	V201 defective.

4.3 ELECTRICAL ADJUSTMENT AND CALIBRATION

4.3.1 Reference Cell Replacement

The mercury reference cell must be replaced periodically as its *useful* life expectancy is from three to four months. Small current is continuously drawn from the reference cell to eliminate voltage fluctuations caused by non-continuous duty. Under continuous drain the cell's emf drops slowly at a rate of 5 to 8 millivolts per month as shown in Figure 4-6 until the cell is exhausted, at which time emf drops suddenly to an unusable value. An exhausted reference cell is indicated by inability of the ZERO ADJ control to move the recorder pen from extreme positions. Replacement cells are available from Varian Associates, from Varian Associates recorder representatives, and from electronic parts supply houses. Mallory Type #RM-12R cell should be used.

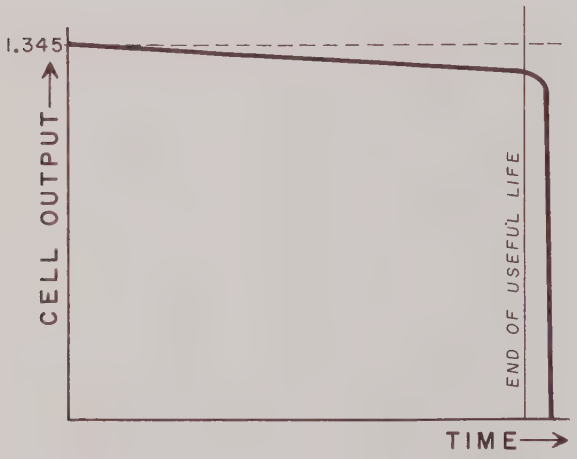


Figure 4-6: Reference Cell Discharge Curve

4.3.2 Calibration

Small changes in electrical and mechanical components with time can cause erroneous indications by the G-11A Recorder. It is advisable to check calibration (1) after replacement of an input chassis or a component such as mercury cell or a tube; (2) after prolonged periods of recorder idleness; (3) periodically, every 3 or 4 months, especially recorders equipped with mercury reference cells; and (4) before making exact quantitative measurements. The recorder is calibrated when its pen indicates values both at the top and bottom of the scale which agree with applied signals.

Adjustment of the Model G-11A Recorder to the desired measurement range requires a precise calibration voltage source. Such a source must provide a stable output voltage accurately known with 0.3 percent or better, and adjustable between 0 and 100 millivolts. The internal resistance of such source must be within the permissible source resistance requirements of the recorder as specified in Section 1.6.1. Varian Recorder Analyzer Model AG-1, or Leeds and Northrup type 8657-C Portable Potentiometer satisfy these requirements. When using L&N type 8657-C Potentiometers or a similar instrument, the galvanometer should be locked or shorted so that emf generated by the movement of the galvanometer coil would not affect the recorder.

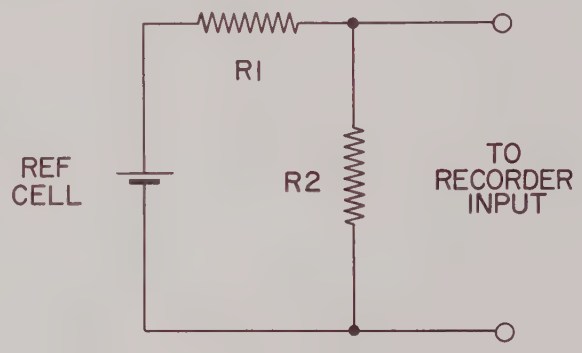


Figure 4-7: Simple Calibration Source

A simple calibration source can be constructed from a spare mercury cell and a voltage divider. Details of construction are shown in Figure 4-7. Span and required resistance values are given in Table III. Note that when the output of such a simplified source is not specifically checked, the use of 1 percent resistors will produce calibration voltages accurate only within 2 percent.

TABLE III
SPAN AND RESISTANCE VALUES

	10 mv	20 mv	50 mv	55 mv
R_1	40K	40K	13K	12.5K
R_2	300 ohms	600 ohms	500 ohms	1K

4.3.2.1 Recorder Calibration—Type A1 and A2 Input Chassis

To calibrate recorders equipped with Types A1 or A2 Input Chassis, proceed as follows:

(1) Connect power cord to a suitable a-c power source and short circuit input terminals.

(2) Turn POWER switch ON. Allow 15 minutes for instrument to warm up. Adjust chart speed controls for a convenient chart speed.

(3) Place recording pen at chart zero position using ZERO ADJ control.

(4) Remove short-circuit and connect a calibration voltage source described in Section 4.3.2. Voltage must be exactly equal to full span value of measurement range.

(5) Adjust CALIBRATE control until recorder pen indicates full span readout.

(6) Disconnect calibration voltage source from recorder and short circuit input terminals. If necessary, adjust position of recorder pen to zero using ZERO ADJ control.

(7) Repeat steps (4), (5), and (6) until no further improvement results.

(8) Check indicating scale to see that it corresponds to chart calibration. If necessary, loosen scale mounting screws and adjust scale until proper alignment is obtained. The recorder is ready to accept input signals.

4.3.2.2 Recorder Calibration—Type B1 Input Chassis

Calibration of recorders equipped with Type B1 Input Chassis is similar to that of Type A1 and A2 Input Chassis, but higher calibration voltages may be required for the higher settings of the VOLTS control. Accuracy of the calibrating voltage source determines the accuracy of recorder calibration. The internal resistance of the calibrating source must meet the specifications of Section 1.6.1. To calibrate, proceed as follows:

(1) Place VOLTS control in the 10-millivolt position (.01). Calibrate the recorder as in Section 4.3.2.1 with a 10-millivolt calibrating voltage.

(2) Calibration at other VOLTS settings are performed similarly, supplying calibrating voltages equal to VOLTS settings.

(3) To check attenuator accuracy, perform calibration as in steps (1) or (2) above.

(4) Switch VOLTS control to a higher setting. The pen will move to a position which is a proportional to the new VOLTS control setting. For example, a 10-mv calibrating voltage will give full span or a reading of 100 on a .01 VOLTS setting, only half span or a reading of 50 on .02 VOLTS setting, 1/5 of full span or a reading of 20 on .05 VOLTS setting, and a reading of 10 on .1 VOLTS control setting. The results should be within 2 percent of full span.

4.3.2.3 Recorder Calibration—Type F1 Input Chassis

Calibration of the recorders equipped with Type F1 Input Chassis is similar to that of recorders equipped with Types A1 and A2 Input Chassis with this exception: the calibration source should have a known constant-current of not more than 1.0 milliampere (the exact value of the source determines the calibration point on the chart scale). A simple calibration source for the F1 Input Chassis, providing approximately 1 milliampere, consists of 10 mercury reference cells in series with a 12K, 1 percent resistor.

4.3.2.4 Recorder Calibration—Type T2 Input Chassis

To calibrate the G-11A Recorder with Type T2 Input Chassis, proceed as follows:

(1) Prepare a crushed ice and water bath in a glass container. A thermos bottle or Dewar flask is preferred. If possible, use distilled water and ice made from distilled water.

(2) Connect power cord to a-c power source.

(3) Insert matching Range Element for thermocouple type and temperature range desired. Use the correct chart paper as shown in Table IV.

(4) Turn POWER switch ON, CHART switch on STANDBY, and allow 15 minutes for instrument to warm up.

(5) See Figure 4-8. Prepare a suitable thermocouple with calibration voltage source connected in series-adding with the thermocouple measuring junction. The calibration voltage source may be connected into the setup using non-thermocouple wires. These wires must be of the same kind (pre-

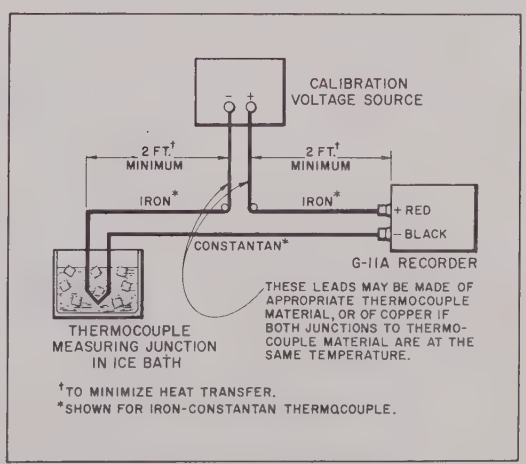

CALIBRATION VOLTAGE SOURCE
2 FT.† MINIMUM
2 FT.† MINIMUM
IRON*
IRON*
+ RED
– BLACK
CONSTANTAN*
G-11A RECORDER
THESE LEADS MAY BE MADE OF APPROPRIATE THERMOCOUPLE MATERIAL, OR OF COPPER IF BOTH JUNCTIONS TO THERMOCOUPLE MATERIAL ARE AT THE SAME TEMPERATURE.
THERMOCOUPLE MEASURING JUNCTION IN ICE BATH
†TO MINIMIZE HEAT TRANSFER.
*SHOWN FOR IRON-CONSTANTAN THERMOCOUPLE.

Figure 4-8: Calibration Voltage Source

ferably consecutive lengths from a wire spool), twisted together and soldered to the thermocouple wire. Insulate solder joints from each other by wrapping them in fiberglass wool, cotton, or strips of cloth.

(6) Set the calibration source for an output which equals the full span voltage for the range element and thermocouple type being used with 0.3 percent. Refer to Table V. (Note that the suggested simple calibration voltage source of Section 4.3.2 is not accurate enough.)

(7) Immerse thermocouple measuring junction in the ice bath for at least 5 minutes, then move CHART switch from STANDBY to a convenient chart speed setting.

(8) Short circuit calibration voltage source. Adjust ZERO ADJ control, bringing the recording pen to 32° F or 0° C position on chart paper.

(9) Remove short from calibration source. Calibration voltage is not applied to recorder terminals.

(10) Adjust CALIBRATE control until recording pen gives proper indication on chart.

(11) Repeat steps (8), (9), and (10) above until no further improvement results.

(12) If necessary, adjust DAMPING and GAIN as in Sections 4.2.1 and 4.3.4.

(13) Repeat steps (8), (9), and (10) if necessary.

(14) Disconnect calibration setup. The recorder is now ready to accept thermocouple input signals.

TABLE IV

RANGE ELEMENTS, CHART PAPER TYPES, RECORDER SCALES

*Fahrenheit Calibration**		*Range Element*	*Chart Type*	*Scale*
0° to 400° F	(I-C type J)	01	101A	101-201
0° to 600° F	(I-C type J)	02	102A	102-202
0° to 750° F	(I-C type J)	03	103A	103-203
0° to 1100° F	(I-C type J)	04	104A	104-204
0° to 1800° F	(I-C type J)	05	105A	105-205
0° to 2200° F	(C-A type K)	06	106A	106-206
−150° to +250° F	(C-C type T)	07	107A	107-207
30° to 220° F	(I-C type J)	09	109A	109-209
30° to 2750° F	(P-PR type R)	10	110A	110-210
Centigrade Calibration		*Range Element*	*Chart Type*	*Scale*
−20° to +200° C	(I-C type J)	01	201A	101-201
−20° to +300° C	(I-C type J)	02	202A	102-202
−20° to +400° C	(I-C type J)	03	203A	103-203
−20° to +600° C	(I-C type J)	04	204A	104-204
−20° to +1000° C	(I-C type J)	05	205A	105-205
−20° to +1200° C	(C-A type K)	06	206A	106-206
−100° to +120° C	(C-C type T)	07	207A	107-207
−200° to +50° C	(C-C type T)	08**	208A	208
0° to +100° C	(I-C type J)	09	209A	109-209
0° to +1500° C	(P-PR type R)	10	210A	110-210

* I-C—Iron-Constantan
C-A—Chromel-Alumel
C-C—Copper-Constantan
P-PR—Platinum-Platinum 13% Rhodium

** Element 08, chart, and scale are available in centigrade calibration only, but range element covers the −325° to +125° F range.

TABLE V
RANGE ELEMENT CALIBRATION VOLTAGE CHART

Range Element	Full Span Calibration From 32° F	Voltage in Millivolts From 0° C
01	11.03	10.78
02	17.18	16.33
03	21.79	21.85
04	32.72	33.11
05	56.64	57.70
06	49.05	48.89
07	5.28	5.23
08	2.11	2.04
09	5.51	5.27
10	17.36	17.49

4.3.2.5 Recorder Calibration—Type T2 Chassis with Displaced Zero Range

Recording ranges including temperatures both above and below 0° C, such as −150 to 250° F or 100 to 120° C, require a modified calibration procedure.

Most thermocouple tables (such as U. S. Department of Commerce Reference Table for Thermocouples, NBS Circular 561, or Instrument Society of America Temperature-EMF Tables for Thermocouples) give the emf of the various thermocouple types using the temperature of melting ice as zero. For example, the tables above show for the copper-constanan thermocouple −3.349 mv for −100 C, +5.227 mv for +120 degrees C and 0 mv for 0 degrees C. Such division of emf values in positive and negative parts indicates the calibration of a displaced zero range can be conveniently performed in two parts — one covering the range below the temperature of melting ice, and the other above the temperature of melting ice.

Therefore, to calibrate a temperature range having displaced zero, proceed as follows:

(1) Calibrate first for the portion of the range above the temperature of melting ice, as in Section 4.3.2.4.

(2) Reverse polarity of the calibration voltage source and calibrate for the portion of the range below the temperature of melting ice.

(3) Repeat steps (1) and (2) until no further improvement results.

4.3.2.6 Recorder Calibration—Type T2 Chassis with Suppressed Zero Range

A different calibration procedure must be employed for suppressed zero ranges. The temperature of melting ice is either below or above — but not within the range of measurement. Examples of such ranges are −200 to −100 degrees C, or 1200 to 1700 degrees C.

To calibrate a suppressed zero range:

(1) Connect calibration voltage source as shown in Figure 4-8.

(2) Set calibration source to voltage corresponding to *lowest* desired temperature of measurement range.

(3) Adjust ZERO ADJ until pen rests at the low end of chart calibration.

(4) Set calibration source to voltage corresponding to *highest* desired temperature of measurement range.

(5) Adjust CALIBRATE control until pen rests at high end of chart calibration.

(6) Repeat steps (2), (3), (4) and (5) until no further improvement results.

(7) Disconnect calibration setup. The recorder is calibrated to accept thermocouple signals in the desired range.

4.3.3 Recorder Span Adjustment

Types A1 and A2 Input Chassis are provided with a control which allows adjustment of the recorder measurement span for any value between 9 and 100 millivolts. Span is set at the factory to the value specified at time of purchase. If span is to be changed, the adjustment can be made as follows:

(1) Remove recorder assembly from case as in Section 4.4.1, observing warning note. Place recorder assembly on grounded metal plate to simulate shielding effects of case.

(2) Short-circuit input terminals, and rotate the DAMPING control to extreme clockwise position.

(3) See that the correct tube is installed according to Table VI for the span desired.

(4) Connect power cord to a-c power source and turn POWER switch ON. Allow several minutes for warmup.

(5) Adjust chart speed controls for a convenient chart speed.

(6) Place recording pen at zero position using ZERO ADJ control.

(7) Remove short-circuit across input terminals and connect an accurately known, adjustable calibration voltage source to input terminals. See Section 4.3.2 for discussion of calibration voltage sources.

TABLE VI V202 TUBE TYPES

Span	Tube Type
9-18 mv	12AX7
19-50 mv	12AT7
51-100 mv	12AU7

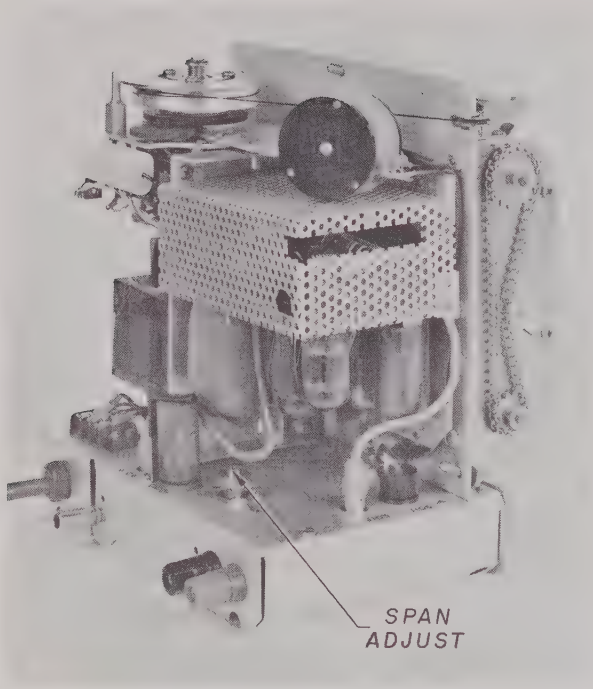


Figure 4-9: Span Control

(8) Adjust calibration voltage source to desired full span value.

(9) Unlock and rotate SPAN control located on top of input chassis (Figure 4-9) until recording pen shows approximately full-scale deflection. Lock SPAN control.

(10) Adjust GAIN control as in steps (5) through (7), Section 4.3.4.

(11) Adjust DAMPING as in Section 4.2.1.

(12) Replace recorder in case.

(13) Make notation of new span value.

(14) Re-calibrate the recorder as in Section 4.3.2.1.

4.3.4 Amplifier Gain Adjustment

Aging of tubes and the difference in signal levels with different recording spans necessitates an occasional GAIN adjustment. The GAIN control (see Figure 4-10) is located in the lower left corner on front of the recorder assembly and is a screwdriver adjustment. To adjust the gain of the amplifier proceed as follows:

(1) Connect power cord to a-c power source and turn POWER switch ON. Allow a few minutes for warmup.

(2) Short-circuit input terminals.

(3) Rotate the DAMPING control to extreme clockwise position.

(4) Adjust chart speed controls for a convenient chart speed.

(5) Rotate GAIN control to extreme clockwise position.

(6) Rotate ZERO ADJ control slightly. Recording pen should oscillate or jitter.

(7) With recording pen oscillating, slowly turn GAIN control in counterclockwise direction until oscillation just ceases. Gain is now set at the optimum value.

(8) Return pen to zero position on chart paper using ZERO ADJ control.

4.4 MECHANICAL ADJUSTMENTS AND SERVICE

4.4.1 Removal of Recorder Assembly from Case

WARNING

Operation of recorder outside of case should be performed with due regard to high voltages present at the servo motor, amplifier, and terminal strips.

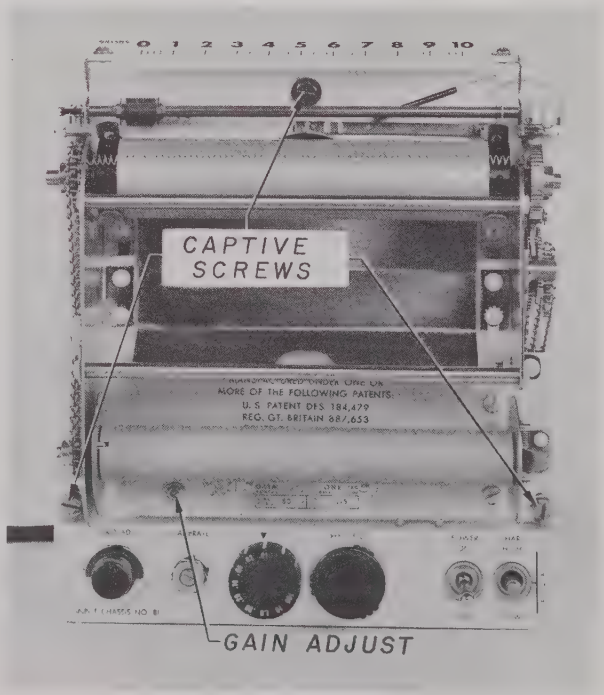


Figure 4-10: Gain Control and Captive Screws

(1) Unplug line cord and remove connections to the recorder terminals. Disconnect event marker actuating connections, if present.

(2) Remove instrument cover by depressing cover release buttons on sides of cover and swinging bottom of cover forward and up.

(3) Remove recorder pen from pen holder.

(4) Completely loosen three captive screws at upper center and lower right and left corners of recorder assembly. See Figure 4-10.

(5) Remove recorder assembly from case by sliding assembly forward and lifting it out. Pass line cord through hole in right-rear corner of case.

(6) Reverse above procedure to install recorder assembly in case.

4.4.2 Input Chassis Removal or Replacement

(1) Remove recorder assembly from case as in Section 4.4.1.

(2) Disconnect plugs from J103, J104, and J105.

(3) Remove input chassis mounting screws through holes in corners of chassis cover. See Figure 4-11.

(4) Remove input chassis from recorder assembly.

(5) If input chassis is replaced, transfer chopper (CH101) to new input chassis and secure proper clamp.

(6) Reverse above procedure to install input chassis.

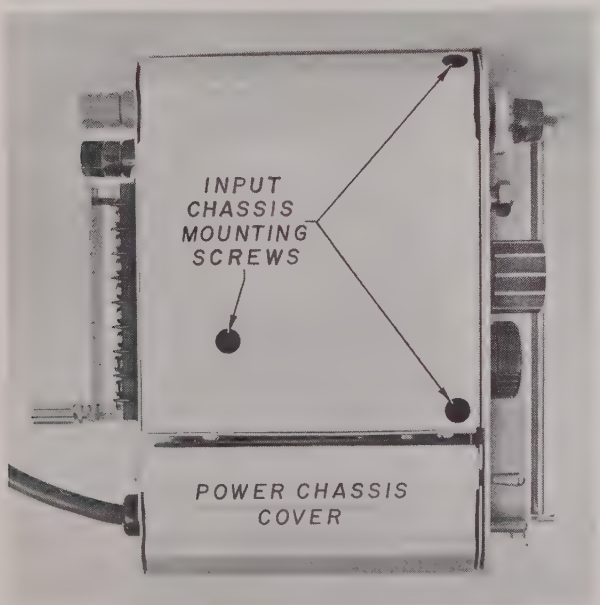


Figure 4-11: Input Chassis Removal

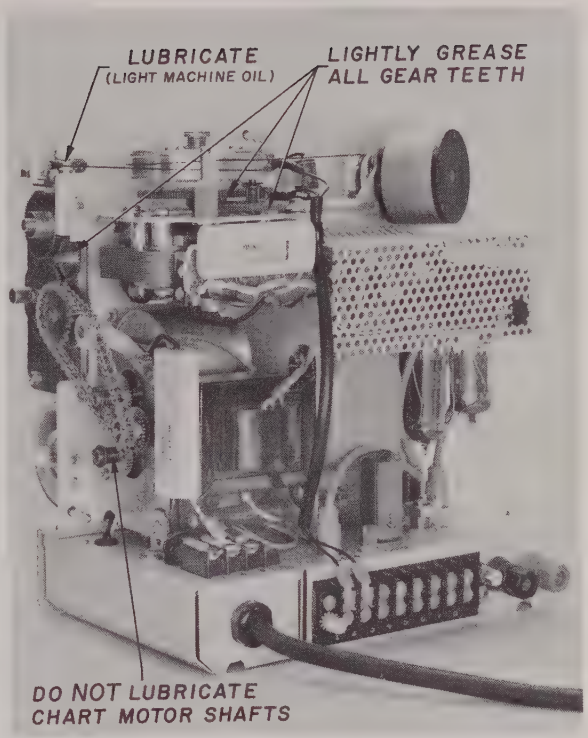


Figure 4-12: Lubrication Points

4.4.3 Lubrication

Bearing and other friction points on Model G-11A Recorders must be lubricated periodically. Use light machine oil (S.A.E. 10) for general lubrication. Use light grease (Lubriplate #110, Fisk Brothers Refining Co.) on servo motor and chart drive gears. Apply grease sparingly. *DO NOT* overgrease.

Perform lubrication at 6-month intervals with exception of the servo motor bearing, which should receive one or two drops of oil every three months. See Figure 4-12.

NOTE

DO NOT lubricate pen-carriage rod nor bearing, as this may trap dust and adversely affect performance of recorder. Instead, periodically clean pen-carriage with a dry lint-free cloth.

4.4.4 Recorder and Event Marker Pen Care

Recorder and event marker pens function properly when ink containers and capillary tubes are kept clean. If caps are not installed, or if recording ink is allowed to dry in pens, the capillary tubes may be obstructed.

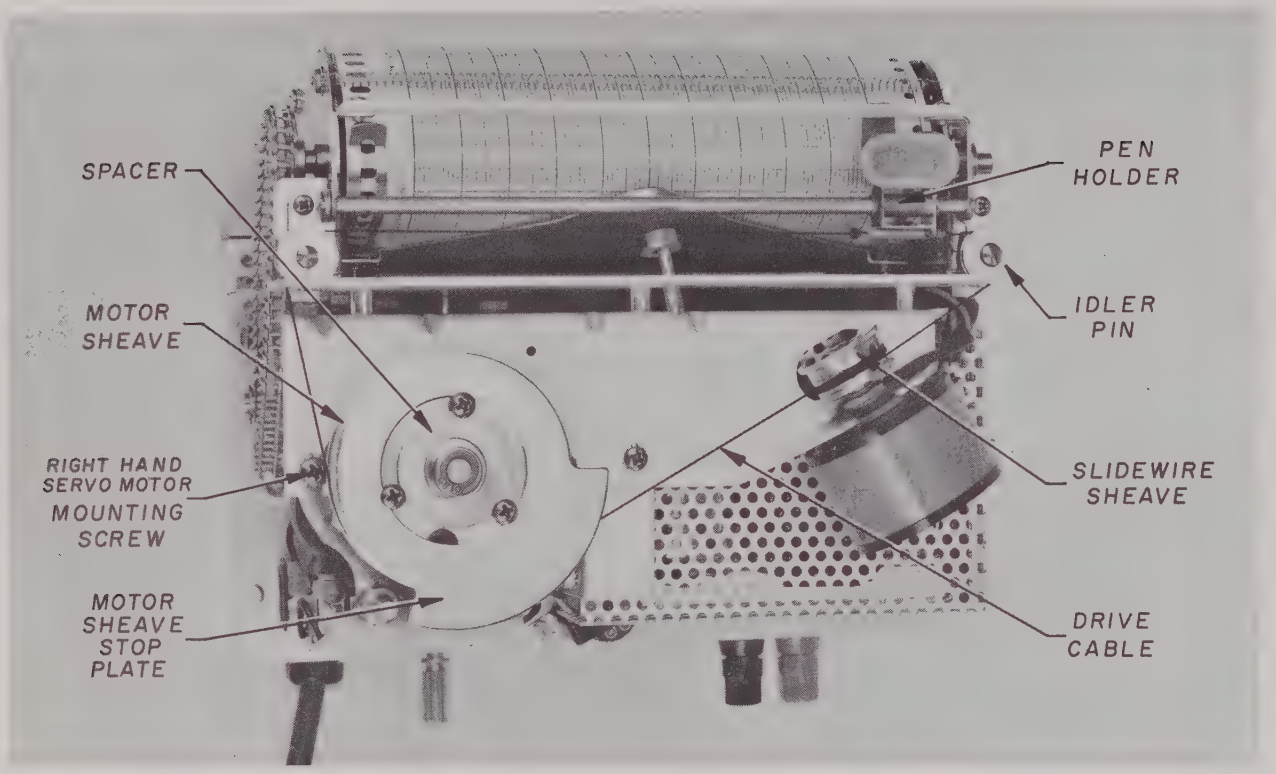


Figure 4-13: Slack Adjustment and Pen Drive Cable Installation

Inks used for the pens are water soluble. Tap water may be used for cleaning. Heavy accumulation of dried ink may require warm soapy water, alcohol, or a commercial pen cleaning fluid. When cleaning, check pen for unobstructed ink flow by filling the ink container with water, replacing cap, and exerting thumb pressure on the cap. If the capillary tube is unobstructed and the pen is clean, water will be forced through the pen. If pen is obstructed, insert a wire through the capillary tube from container side and flush pen with water. *Never allow ink to dry in pens.* Pens should be flushed immediately after use. Minimize ink drying by keeping plastic caps in place. Keep all metal parts of the recorder free from ink since recorder inks may be corrosive.

4.4.5 Pen Drive Cable Assembly

Small amounts of slack in the pen drive cable may be removed by loosening the right-hand servo motor mounting screw (viewed facing front of recorder) and shifting the position of the motor toward the rear of the recorder. See Figure 4-13. To remove large amounts of slack, re-tie cable to pen-carriage springs. If necessary, remove cable and refer to Section 4.4.6 below.

4.4.6 Pen Drive Cable Installation

To install a new drive cable, proceed as follows, consulting Figures 3-11 and 4-13 for parts nomenclature and locations.

(1) Remove recorder assembly from case as in Section 4.4.1.

(2) Remove motor sheave stop-plate by removing three screws and large spacer.

(3) Remove old drive cable from recorder. Save springs on pen holder.

(4) Loosen right-hand servo motor mounting screw and fully insert screw in mounting slot. Tighten screw.

(5) Cut a section of drive cable at least 40 inches long and make a loop approximately 12 inches from one end.

(6) Crimp loop and insert into anchor post access hole on side of slidewire sheave and fasten loop over anchor post on flat side of sheave. Pull both ends of cable to tighten loop around post.

(7) Rotate slidewire sheave to extreme clockwise position (viewed from front of recorder).

(8) Loosen set screws on slidewire sheave and rotate sheave, placing anchor post at highest vertical point. Tighten set screws.

(9) Take short end of drive cable and make three counterclockwise turns around sheave progressing toward slidewire. Make sure that cable is not twisted and does not overlap. Place tape over cable turns on sheave to prevent cable from unwinding.

(10) Move pen carriage to extreme left position. Place drive cable around left-hand idler pulley and slip cable through small spring at rear of pen carriage. Do not move sheave.

(11) Rotate slidewire sheave approximately 1/4 turn in counterclockwise direction (this places slidewire contact in most desirable operating range).

(12) Hold slidewire sheave stationary and remove all slack between sheave and spring on pen carriage. Note point where cable engages spring.

(13) Remove spring and secure cable to spring at point noted in step (11). Use a firm overhand knot. Replace spring on pen-carriage.

If cable is properly attached, clockwise rotation of slidewire sheave will not move sheave or pen carriage.

(14) Rotate servo motor sheave so that anchor post on side of sheave is at rear of recorder.

(15) Make loop in cable approximately 14 inches from slidewire sheave. Crimp loop, insert it through anchor post hole, and fasten loop to anchor post on bottom of sheave.

(16) Rotate servo motor sheave in clockwise direction (viewed from top of recorder) to wind excess cable around sheave. Place tape over cable turns. If cable is properly attached, anchor post hole will again be at rear of recorder.

(17) Attach large tension spring to slot in rear of pen carriage.

(18) Take loose end of cable, which should be below the cable turns on sheave, and place cable around right-hand idler pulley. Attach cable to tension spring with firm overhand knot.

(19) Proper cable tension is achieved when tension spring is directly in line with drive cable and parallel to pen carriage rod.

(20) Remove tape from sheaves and check installation by placing recorder in operation and rotating ZERO ADJ control. All balancing system components should move simultaneously throughout full range of travel.

(21) Install motor sheave stop-plate and spacer removed in step (2). Tighten three screws.

4.4.7 Takeup Chain Adjustment

Tension on the takeup chain may be adjusted by proper positioning of the idler-pulley arm on the left side of the recorder. See Figure 4-14. Takeup chain tension is determined by applying light finger pressure perpendicular to free length of chain. If chain moves more than 1/4-inch, chain tension should be increased.

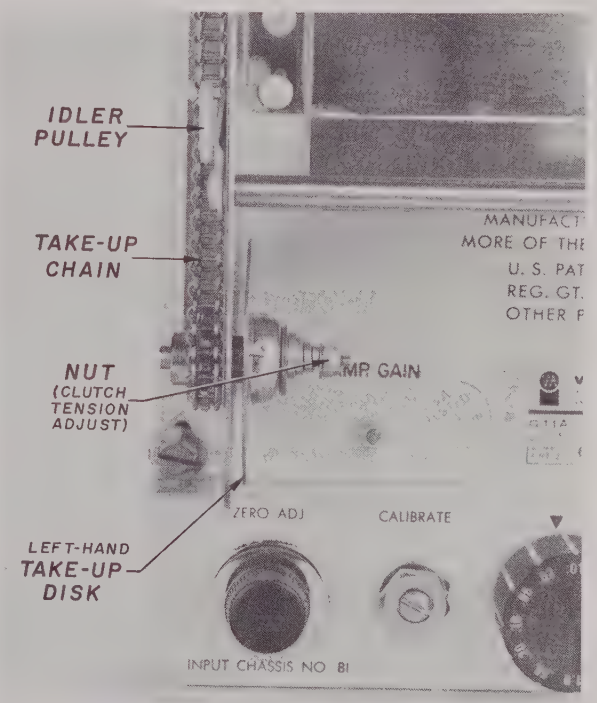


Figure 4-14: Chart Takeup System

4.4.8 Chart Takeup Adjustment

If chart paper has tendency to pull at the sprocket teeth, thread chart paper over chart retainer spring. If takeup clutch tension is incorrect, or chart paper re-roll is unbalanced, proceed as follows:

(1) Remove recorder front cover.

(2) Remove cardboard re-roll tube by swinging right-hand takeup disk to right.

(3) Hold left-hand takeup disk securely and tighten nut on right-hand end of takeup shaft to increase takeup clutch tension and roll chart paper tightly. To decrease takeup clutch tension loosen stop nut

on takeup shaft. Check operation and repeat the adjustment until desired chart paper tension is obtained.

(4) To equalize chart paper takeup, remove recorder assembly from case as in Section 4.4.1, loosen two screws holding hinged assembly on right front side of recorder, and adjust hinged assembly as follows:

If tension is greater at right-hand side of chart paper, move hinged assembly up and tighten screws. If tension is greater at left-hand side of chart paper, move hinged assembly down and tighten screws. Check chart operation and repeat adjustment until even operation is obtained.

4.4.9 Chart Speed Changes or Additions

The chart speed of the recorder may be changed by replacing individual chart motors. Chart speed in inches per minute or inches per hour is twice the speed that is stamped on chart motor housing. Consult Figure 4-15 for parts nomenclature. To replace chart motor, proceed as follows:

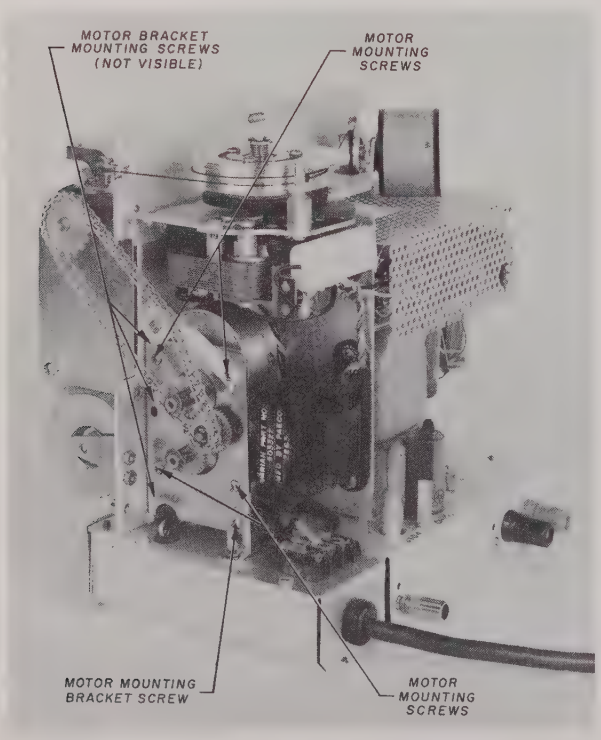


Figure 4-15: Chart Motor Mounting

(1) Disconnect power cord from a-c power line. Disconnect signal cables attached to input terminals and event marker actuating connections, if used.

(2) Remove recorder assembly from case as in Section 4.4.1.

(3) Disconnect chart drive motor terminals from terminal block TB201. The high-speed motor is always connected to terminals 2 and 3.

(4) Remove chart motor assembly mounting bracket by removing three screws in front panel and single screw in vertical panel of angle bracket.

(5) Remove motor to be replaced from mounting bracket by removing mounting screws.

NOTE

High-speed motors of Group 2, Table I, which must be installed always in upper position on mounting bracket, require the addition of a resistor, a capacitor, and terminal strip. Replacement motors for Model G-11A Recorders are available from the factory.

(6) Install replacement chart motor on motor assembly mounting bracket. Connect high-speed motor to terminals 2 and 3 of TB201. Make certain ladder chain is installed before attaching mounting bracket to recorder chassis.

(7) Adjust ladder chain tension as in Section 4.4.7.

4.4.10 Event Marker Adjustment

Pressure on the event marker pen point is maintained by the spring between the event marker carriage link and the notch at the upper right side of the recorder chassis. Pressure on the event marker pen should be adjusted so the pen just maintains contact with the chart paper. To increase or decrease pen pressure, move the tension spring to the left or right respectively. To adjust the displacement of the pen, loosen the two relay mounting screws and position the relay as desired. When making this adjustment, verify full-span position of recording pen.

NOTE

Do not operate event marker repeatedly without advancing chart paper.

parts list

MECHANICAL PARTS LIST

Reference Number	Part Description	Varian Part Number
INPUT CHASSIS (ALL)		
1	Cap, reference cell holder	901043
2	Clamp assy., chopper	902016
	Cover, chassis	941489
3	Holder, reference cell	901038
4	Knob, zero adjust	23-519 990
5	Ring, locking, zero adjust	904560
AMPLIFIER CHASSIS		
6	Clamp, tube	22-149 913
7	Clamp, tube	22-149 912
8	Clamp, cable	22-199 803
9	Cover assy., amplifier	902379
10	Shield, tube	24-282 960
SERVO CHASSIS		
11	Cable, pen drive (52-inch length)	88-589 990
12	Disk, clutch	901707
	Hook, cord	901977
13	Pin, drive, balancing motor extension shaft	19-224 990
14	Plate, stop, sheave	903858
15	Ring, retainer	22-678 944
16	Spacer, clutch	901708-01
17	Sheave assy., balancing motor	901711
18	Sheave assy., slidewire	900756
19	Shaft, extension, balancing motor	901717
20	Spring, servo clutch	901709
	Spring, pen drive cable	903461
21	Stop, sheave	903857

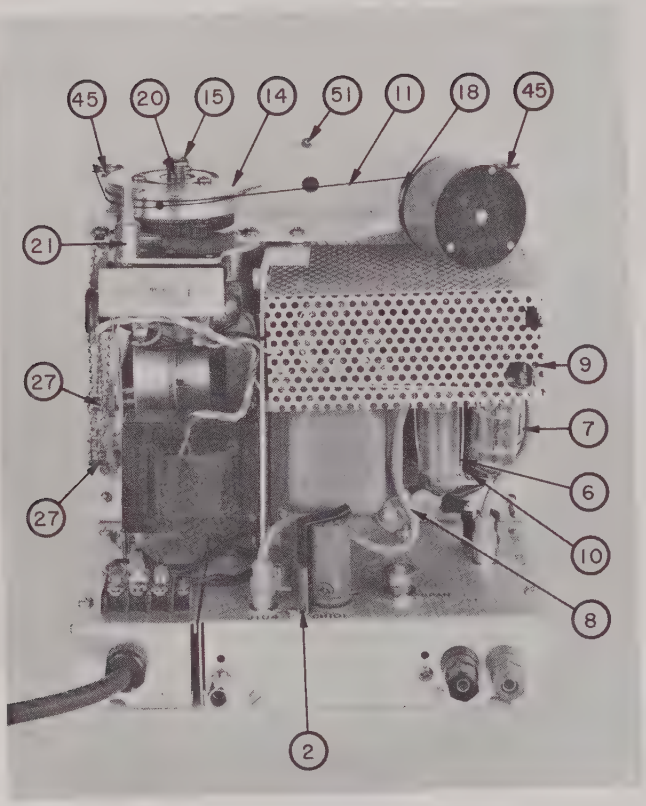


Figure 5-1: Mechanical Parts List

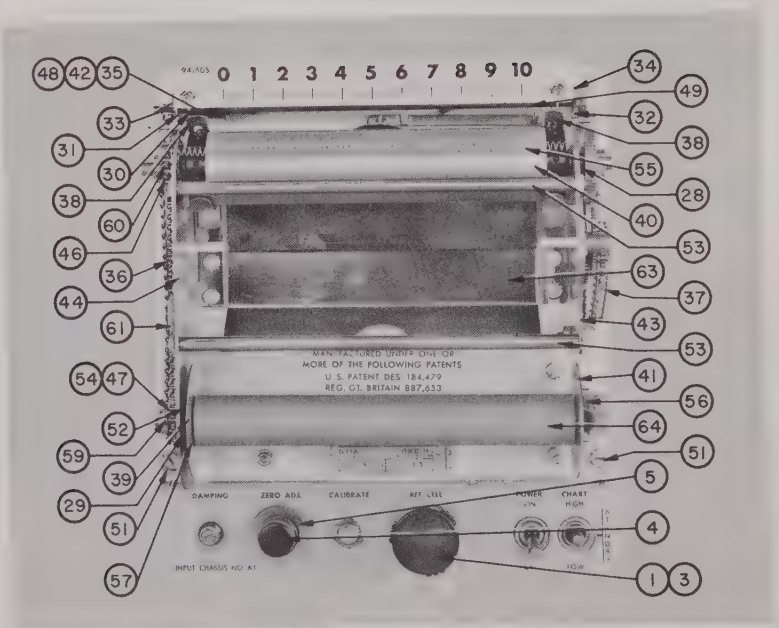


Figure 5-2: Mechanical Parts List

MECHANICAL PARTS LIST (cont)

Reference Number	Part Description	Varian Part Number
DRIVE MOTOR ASSEMBLY		
22	Bushing, drive motor shaft	901124
23	Gear, idler, chart drive	901125
24	Gear assy., chart motor	901128
25	Ring, retainer	22-678 815
26	Ring, retainer	22-678 944
27	Spring	901127
CHART DRIVE ASSEMBLY		
28	Bearing, chart drum shaft	23-139 805
29	Bearing, take-up	23-139 804
30	Bearing, pen carriage	21-139 914
31	Bracket, rh, mounting, pen carriage rod	900964-01
32	Bracket, lh, mounting, pen carriage rod	900964-02
33	Bracket, indicating scale, lh	901167-02
34	Bracket, indicating scale, rh	901167-01
35	Carriage, recording pen	900970
36	Chain, chart take-up	901327-01
37	Chain, drive (units with speed shifter)	901327-03
	Chain, drive (units without speed shifter)	901327-02
38	Clip, chart	904702
39	Clutch assy., take-up	900966
40	Drum assy., chart	901095
41	Hinged center assy.	901097
42	Pen carriage assy.	901165
43	Plate assy., rh	900989
44	Plate assy., lh	900990
	Platen, chart compartment cover	900999
45	Pulley, idler, pen drive cable	901028
46	Ring, retainer, chart drum shaft bearing	22-678 837
47	Ring, retainer, take-up bearing	22-678 831
48	Ring, retainer, recording pen carriage	22-678 825

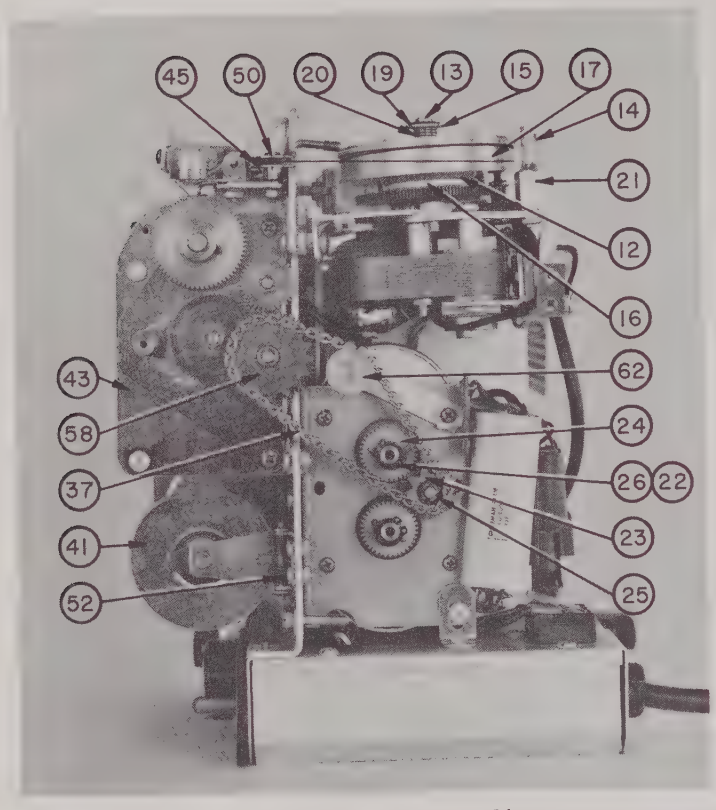


Figure 5-3: Mechanical Parts List

Figure 5-4: Mechanical Parts List

Reference Number	Part Description	Varian Part Number
49	Rod, pen carriage	900961
50	Screw, shoulder, pen drive cable idler	901027
51	Screw, captive, for securing recorder to case	901326
52	Spacer, bearing	901029
53	Spacer, chassis	900965
54	Spacer, clutch	901460
55	Spring, chart retainer	901616
56	Spring, hinge, hinge center assy.	900957
57	Spring, take-up clutch	21-719 930
	Sprocket, chart drive (units without speed shifter)	900991
58	Sprocket, chart drive (units with speed shifter)	901123
59	Sprocket, chart take-up assy.	900992
60	Sprocket, drive, chart drive take-up assy.	900991
61	Take-up assy., chain	901461
62	Take-up assy., chart drive	903037
63	Trough, chart, chart paper holder	942466
64	Tube, re-roll	901279
EVENT MARKER AND PEN LINK ASSEMBLY		941586-02
65	Carriage Link	941585
66	Hose, ink	88-494-716
67	Ink Reservoir Assembly	902022
68	Pen and Ink Assembly	941586-01
69	Plastic Well Cover	900867-01
70	Spring, extension	902741

CHART DRIVE MOTOR PART NUMBERS:

G-11 and G-11A, 60 CYCLE

For G-11 and G-11A

Chart Speed	Motor Speed	Part No. for Motor only	Part No. for Motor Assembly (includes gear, spade lugs, slip clutch and mounting hardware)
1/2"/hr	6RPD, 1/4 RPH	941587-01	941588-01
1"/hr	1/2 RPH	941587-03	941588-03
2"/hr	1 RPH	941587-04	941588-04
3"/hr	1/40 RPM	941587-07	941588-07
8"/hr	4 RPH, 1/15 RPM	940657-05	940503-05
12"/hr	6 RPH, 1/10 RPM	940657-08	940503-08
15"/hr	1/8 RPM	940657-17	940503-14
20"/hr	10 RPH, 1/6 RPM	940657-09	940503-09
24"/hr	12 RPH, 1/5 RPM	940657-16	940503-13
30"/hr	15 RPH, 1/4 RPM	940657-10	940503-10
1"/min	1/2 RPM	940657-11	940503-11
2"/min	1 RPM	940657-12	940503-12

For G-11A only, Serial No. 678A and Above

		Motor Only	Motor Assembly (includes phase shifting resistor and capacitor)
4"/min	2 RPM	902365-01	941114-01
6"/min	3 RPM	902365-02	941114-02
8"/min	4 RPM	902365-03	941114-03

For G-11 only, through Serial No. 677

		Motor Only	Motor Assembly
4"/min	2 RPM	940657-13	940962-01
6"/min	3 RPM	940657-14	940962-02
8"/min	4 RPM	940657-15	940962-03

NOTE: Some motors listed above are also used on recorder models other than G-11A. They provide the particular chart speed shown above only when used in the G-11A Recorder. Used in another model, they will provide a different chart speed.

To avoid confusion when ordering, please include the recorder model number whenever reference is made to a chart speed. The part number will also provide positive identification of the item required.

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
A1 INPUT CHASSIS:			960645
BT101	Battery, mercury cell, 1.34v, 250 ma. max.	Mallory RM-12R	74-101-550
C101	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
C102	Capacitor, fixed, mylar, 0.47 μf, 150v, ±20%	Gudeman No. 343-012M	41-719-886
C103	Capacitor, fixed, paper, 0.022 μf, 400v, ±10%	Sprague No. 109P22394	41-346-852
C105	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
CH101	Chopper, 7 pin min., 6.3 vac	Varian	901335
J101	Connector, binding post, red, 30a, 1000v	Superior Elec.Co. DF 30 RC	51-799-999
J102	Connector, binding post, black, 30a, 1000v	Superior Elec.Co. DF 30 BC	51-799-990
J103	Receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J104	Receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J105	Receptacle, socket, electron tube, 3 contacts	Amphenol No. 78-535	54-233-990
J107	Receptacle, socket, electron tube, 9 pin miniature	Amphenol No. 59-307	54-297-990
J108	Post, binding,	Varian	901515-02
R101	Resistor, variable, ww, 20k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-20K	37-586-520
R102	Resistor, fixed, comp., 470k, 1/2w, 10%	Allen-Bradley No. Type EB	32-202-647
R104	Resistor, fixed, deposit carbon, 1k, 1/2w, 1%	Electra Mfg. No. Type DC 1/2 A	31-674-100
R105	Resistor, variable, comp., 5k, 2w	Allen-Bradley No. JAIL048S504AC	36-895-450
R106	Resistor, variable, ww, 1.5k, 2w, ±5%	Clarostat Mfg. No. 4362-1500	37-586-415
R107	Resistor, fixed, deposit carbon, 1.5k, 1/2w, ±1%	Electra Mfg. Co. No. Type DC 1/2 A	31-674-150
R108	Resistor, fixed, deposit carbon, 27.4k, 1/2w, ±1%	Electra Mfg. Co. No. Type DC 1/2 A	31-675-274
R109	Resistor, variable, ww, 20k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-20K	37-586-520
R110	Resistor, fixed, comp., 100k, 1/2w, 10%	Allen-Bradley No. Type EB	32-202-610

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
A 2 INPUT CHASSIS:			960501
C101	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
C102	Capacitor, fixed, mylar, 0.47 μf, 150v, ±20%	Gudeman No. 343-012M	41-719-886
C103	Capacitor, fixed, paper, 0.022 μf, 400v, ±10%	Sprague No. 109P22394	41-346-852
C105	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
C301	Capacitor, fixed, electrolytic, 80 μf, 6v, -20% +60%	Barco Inc. No. P6-80	41-509-999
C302	Capacitor, fixed, electrolytic, 80 μf, 7v, -20% +60%	Barco Inc. No. P6-80	41-509-999
C303	Capacitor, fixed, electrolytic, 80 μf, 7v, -20% +60%	Barco Inc. No. P6-80	41-509-999
CR301	Diode, type IN34A, 6v, -50 +90°C		66-398-990
CR302	Diode, type IN468, zener, 4.3 to 5.4v	Hoffman No. A4-B	66-397-943
CH101	Chopper, 7 pin minature, 6.3 vac	Varian	901335
J101	Connector, binding post, red, 30a, 1000v	Superior Elec. Co. No. DF 30 RC	51-799-999
J102	Connector, binding post, black, 30a, 1000v	Superior Elec. Co. No. DF 30 BC	51-799-990
J103	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J104	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J105	Receptacle, socket, electron tube, 3 contacts	Amphenol No. 78-535	54-233-990
J107	Receptacle, socket, electron tube, 9 pin miniature	Amphenol No. 59-307	54-297-990
J108	Post, binding	Varian	901515-02
R101	Resistor, variable, ww, 20k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-20K	37-586-520
R102	Resistor, fixed, comp., 470k, 1/2w, ±10%	Allen-Bradley No. type EB	32-202-647
R105	Resistor, variable, comp., 500k, 2w, 10%	Allen-Bradley No. JAIL048S504AC	36-895-450
R108	Resistor, fixed, deposited carbon, 27.4k, 1/2w, ±1%	Electra Mfg. Co. No. Type DC 1/2 A	31-675-274
R109	Resistor, variable, ww, 10k, 2w, ±5%	Clarostat Mfg Co. No. 43C2-10K	37-586-510
R110	Resistor, fixed, comp., 100k, 1/2w, ±10%	Allen-Bradley No. type EB	32-202-610
R301	Resistor, fixed, deposited carbon, 4.75k, 1/2w, 1%	Electra Mfg. Co. No. Type DC 1/2 A	31-674-475
R303	Resistor, variable, ww, 1.5k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-1500	37-586-415
T301	Transformer, isolation, electronic supply	Varian	901723

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
B1 INPUT CHASSIS:			960961
BT101	Battery, mercury cell, 1.34v, 250 ma max.	Mallory RM-12R	74-101-550
C101	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
C102	Capacitor, fixed, mylar, 1 μf, 200v	Gudeman No. 338C105M	41-729-897
C103	Capacitor, fixed, paper, 0.022 μf, 400v, ±10%	Sprague No. 109P22394	41-346-852
C105	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
CH101	Chopper, 7 pin min. 6.3 vac	Varian	901335
J101	Connector, binding post, red, 30a, 1000v	Superior Elec. Co. No. DF 30 RC	51-799-990
J102	Connector, binding post, black, 30a, 1000v	Superior Elec. Co. No. DF 30 BC	51-799-990
J103	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J104	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J105	Receptacle, socket, electron tube, 3 contacts	Amphenol No. 78-535	54-233-990
J107	Receptacle, socket, electron tube, 9 pin miniature	Amphenol No. 59-307	54-297-990
J108	Post, binding	Varian	901515-02
R101	Resistor, fixed, deposited carbon, 9 meg, 2w, 1/2%	Electra Mfg. Co. DC2	31-887-790
R102	Resistor, fixed, deposited carbon, 900k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-690
R103	Resistor, fixed, deposited carbon, 50k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-550
R104	Resistor, fixed, deposited carbon, 30k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-530
R105	Resistor, fixed, deposited carbon, 10k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-510
R106	Resistor, fixed, deposited carbon, 5k, 1/2 w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-450
R107	Resistor, fixed, deposited carbon, 3k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-430
R108	Resistor, fixed, deposited carbon, 1k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-410
R109	Resistor, fixed, deposited carbon, 1k, 1/2w, 1/2%	Electra Mfg. Co. DC 1/2 A	31-684-410
R110	Resistor, fixed, comp., 47k, 1/2w, 10%	Allen-Bradley EB	32-202-547
R111	Resistor, fixed, comp., 220k, 1/2w, 10%	Allen-Bradley EB	32-202-622
R112	Resistor, fixed, deposited carbon, 47.5k, 1/2w	Electra Mfg. Co. DC 1/2 A	31-675-475
R113	Resistor, variable, comp., 5k, 2w, 10%	Allen-Bradley No. JAIL100S502UA	36-895-450
R114	Resistor, variable, ww, 1.5k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-1500	37-586-415
R115	Resistor, fixed, deposited carbon, 1k, 1/2w, 1%	Electra Mfg.Co. DC 1/2 A	31-674-100
R116	Resistor, fixed, deposited carbon, 1k, 1/2w, 1%	Electra Mfg. Co. DC 1/2 A	31-674-100
S101A	Switch, attenuator	Varian	941295

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
F1 INPUT CHASSIS:			960648
BT101	Battery, mercury cell, 1.34v, 250 ma. max.	Mallory RM-12R	74-101-550
C101	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
C102	Capacitor, fixed, mylar, 0.47 μf, 150v, ±20%	Gudeman No. 343-012M	41-719-886
C103	Capacitor, fixed, paper, 0.022 μf, 400v, ±10%	Sprague No. 109P22394	41-346-852
C104	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
C105	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C105M	41-729-897
CH101	Chopper, 7 pin miniature, 6.3 vac.	Varian	901337
J101	Connector, binding post, red, 30a, 1000v	Superior Elec. Co. No. DF 30 RC	51-799-999
J102	Connector, binding post, black, 30a, 1000v	Superior Elec. Co. No. DF 30 BC	51-799-990
J103	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J104	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J105	Receptacle, socket, electron tube, 3 contacts	Amphenol No. 78-535	54-233-990
J107	Receptacle, socket, electron tube, 9 pin miniature	Amphenol No. 59-307	54-297-990
J108	Post, binding	Varian	901515-02
R101	Resistor, fixed, comp., 10k, 1/2w, ±10%	Allen-Bradley EB	32-202-510
R102	Resistor, fixed, comp., 470k, 1/2w, ±10%	Allen-Bradley EB	32-202-647
R104	Resistor, fixed, deposited carbon, 5.6k, 1/2w, ±1%	Electra Mfg. Co. DC 1/2 A	31-674-562
R105	Resistor, variable, comp., linear, 5k, 2w, 10%	Allen-Bradley No. JAIL100S502UA	36-895-450
R106	Resistor, variable, ww, 1.5k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-1500	37-586-415
R107	Resistor, fixed, deposited carbon, 1k, 1/2w, ±1%	Electra Mfg. Co. DC 1/2 A	31-674-100
R108	Resistor, fixed, deposited carbon, 27.4k, 1/2w, ±1%	Electra Mfg. Co. DC 1/2 A	31-675-274
R110	Resistor, fixed, deposited carbon, 1.3k, 1/2w, ±1%	Electra Mfg. Co. DC 1/2 A	31-674-130
R111	Resistor, fixed, deposited carbon, 49.9 ohms, 1/2w, ±1%	Electra Mfg. Co. DC 1/2 A	31-672-499
R112	Resistor, fixed, comp., 27k, 1/2w, ±10%	Allen-Bradley EB	32-202-527
R113	Resistor, variable, ww, 20k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-20K	37-586-520

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
T2 INPUT CHASSIS:			961055
C101	Capacitor, fixed, mylar, 1 μf, 200v, ±20%	Gudeman No. 338C10SM	41-729-897
C102	Capacitor, fixed, mylar, 0.47 μf, 150v, ±20%	Gudeman No. 343-012M	41-719-886
C103	Capacitor, fixed, paper, 0.022 μf, 400v, ±10%	Sprague No. 109P22394	41-346-852
C301	Capacitor, fixed, electrolytic, 80 μf, 6v, -20% +60%	Barco Inc., No. P6-80	41-509-999
C302	Capacitor, fixed, electrolytic, 80 μf, 6v, -20% +60%	Barco Inc., No. P6-80	41-509-999
C303	Capacitor, fixed, electrolytic, 80 μf, 6v, -20% +60%	Barco Inc., No. P6-80	41-509-999
CR301	Diode, type IN34A, 6v, -50 +90°C		66-398-990
CR302	Diode, type IN468, zener, 4.3 to 5.4v,	Hoffman No. A4B	66-397-943
CH101	Chopper, 7 pin miniature, 6.3 vac.	Varian	901335
J101	Connector, binding post, red, 30a, 1000v	Superior Elec. Co. No. DF 30 RC	51-799-999
J102	Connector, binding post, black, 30a, 1000v	Superior Elec. Co. No. DF 30 BC	51-799-990
J103	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J104	Connector, receptacle, phono jack, single female contact	Cinch-Jones Sales No. 81A (8134)	51-471-980
J105	Receptacle, socket, electron tube, 3 contacts	Amphenol No. 78-535	54-233-990
J107	Receptacle, socket, electron tube, 9 pin miniature	Amphenol No. 59-307	54-297-990
J108	Post, binding	Varian	901515-02
R101, R102	Resistors, voltage-dividing network, A and B -815 ohms dc, ±1%; Band C, 11985 ohms, dc, ±.1%	Varian	903414
R103A, R103B	Resistors, variable, ww, dual, max. 8 ohms	Varian	903340
R104	Resistor, temp. sensitive,	Varian	941482
R105	Resistor, variable, ww, 50k, 2w, 5%		37-586-550
R106	Resistor, fixed, ww, 100k, 1/4w, 1/2%	K-F Development Co. No. type M-2	31-299-610
R301	Resistor, fixed, deposited carbon, 4.7k, 1/2w, 1%	Electra Mfg. Co. DC 1/2 A	31-674-475
R303	Resistor, variable, ww, 2.5k, 2w, ±5%	Clarostat Mfg. Co. No. 43C2-2500	37-586-425
T301	Transformer, isolation, electronic supply	Varian	901723
	Range Element (see Varian Sales Data Sheet for Range Element Dash No. and Temperature Range of each)		961190

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
60 CYCLE AMPLIFIER ASSEMBLY:			961243
C201A, C201B, C201C, C201D	Capacitor, fixed, electrolytic, 20-20-20 μf, 400v; 20 uf, 25v	Cornell Dubilier No. D0520	41-548-427
C202	Capacitor, fixed, paper, 0.01 μf	Sprague No. 109P10394	41-346-844
C203	Capacitor, fixed, electrolytic, 6v, 50 μf	Cornell Dubilier BBR 50-6	41-508-816
C205	Capacitor, fixed, paper, 0.01 μf	Sprague No. 109P10394	41-346-844
C206	Capacitor, fixed, paper, 0.01 μf	Sprague No. 109P10394	41-346-844
C207	Capacitor, fixed, electrolytic, 6v, 50 μf	Cornell Dubilier BBR 50-6	41-508-816
C208	Capacitor, fixed, paper, tubular, .001 μf, 400 vdc, ±10%	Sprague No. 109P10294	41-346-800
C209	Capacitor, fixed, paper, tubular, .022 μf, 400 vdc, ±10%	Sprague No. 109P22394	41-346-852
P203	Connector, phono plug, single male contact	Cinch-Jones Sales No. 13A (1336)	51-171-980
P204	Connector, phono plug, single male contact	Cinch-Jones 13A(1336)	51-171-980
R201	Resistor, fixed, comp., .220k, 1/2w, 10%	Allen-Bradley EB	32-202-622
R202	Resistor, fixed, comp., 470k, 1/2w, 10%	Allen-Bradley EB	32-202-647
R203	Resistor, fixed, comp., 47k, 1/2w, 10%	Allen-Bradley EB	32-202-547
R204	Resistor, fixed, comp., 330k, 1/2w, 10%	Allen-Bradley EB	32-202-633
R205	Resistor, fixed, comp., 330k, 1/2w, 10%	Allen-Bradley EB	32-202-633
R206	Resistor, fixed, comp., 22k, 1/2w, 10%	Allen-Bradley EB	32-202-522
R207	Resistor, fixed, comp., 4.7k, 1/2w, 10%	Allen-Bradley EB	32-202-447
R208	Resistor, fixed, comp., 470k, 1/2w, 10%	Allen-Bradley EB	32-202-647
R209	Resistor, fixed, comp., 10k, 1/2w, 10%	Allen-Bradley EB	32-202-510
R211	Resistor, fixed, comp., 4.7k, 1/2w, 10%	Allen-Bradley EB	32-202-447
R212	Resistor, fixed, comp., 470k, 1/2w, 10%	Allen-Bradley EB	32-202-647
R213	Resistor, fixed, comp., 4.7k, 1/2w, 10%	Allen-Bradley EB	32-202-447
R214	Resistor, fixed, comp., 470k, 1/2w, 10%	Allen-Bradley EB	32-202-647
R215	Resistor, ww, 500 ohm, 5w, ±5%,	Sprague 27E	35-289-350
R216	Resistor, variable, ww, 5k, 5%, 0.5% linearity (slidewire)	Varian	901501
R217	Resistor, fixed, comp., 470k, 1/2w, 10%	Allen-Bradley EB	32-202-647
R218	Resistor, variable, comp., 1 meg, 20%	Varian	903344
T201	Transformer, output, 5w, primary impedance, 5k, secondary impedance 1.9k	Varian	903322
T202	Transformer, power, 115 vac. primary	Varian	900767
V201	Tube, electron, type 12AX7	Telefunkin only	61-901-678

ELECTRICAL PARTS LIST

Schematic Reference	Part Description	Manufacturer's Designation	Varian Part No.
V202 (9-18 mv)	Tube, electron, type 12AX7	General Electric	61-900-810
V202 (19-50 mv)	Tube, electron, type 12AT7	General Electric	61-900-799
V202 (51-100 mv)	Tube, electron, type 12AU7	General Electric	61-900-801
V203	Tube, electron, type 6AQ5	General Electric	61-900-375
V204	Tube, electron, type 6X4/6063	General Electric	61-900-715
	Cable, 2-conductor, shielded (22-inch length), 22AWG	Belden Mfg. Co. No. 8737	81-722-298
	Clamp, tube	Tub-Lok Mfg. Co. 102-W	22-149-912
	Clamp, tube	Tub-Lok Mfg. Co. 103-W	22-149-913
	Clamp, cable, .188 dia.	Holub Industries, Inc. No. EC-3	22-119-803
	Shield, tube, miniature, 1-15/16 inch height, 9 pin	Elco Corp. Co. 191-P-35	24-282-750
SERVO CHASSIS:			
B201	Motor, balancing, high-impedance (distinguished by #20 AWG cloth-covered leads; also connecting C212, .68 uf, 400v, capacitor across plate side of T201).	Varian	940389-02
C212	Capacitor, fixed, plastic, .68 μf, 400 vdc, ±20%	Gudeman Co. 338E 684M	41-749-889
P205	Connector, plug, miniature, 3 male contacts	Amphenol No. 71-35	51-183-980
R216	Resistor, variable, ww, 5k, 5%, 0.5% linearity (slidewire)	Varian	901501
POWER CHASSIS			940968
F201	Fuse, 1/4" x 1", 1a,	Littelfuse No. 361001	67-121-410
L201	Filter, Interference	Varian	902304
L202	Inductor, filter	Varian	940648
P206	Cable, power (including plug), 3 wire	Varian	901187
S201	Switch, toggle, SPST, 2-contact, 3a-250v, 6a-125v	Carling Elec. Inc. 110B-73	71-119-980
S202	Switch, toggle, DPDT, 2-contact, 20a-125v, 10a-250v	Arrow-Hart and Hegeman No. 82609	71-149-960
TB201	Board, terminal	Varian	901800
	Fuseholder, black, 1 pole	Bussmann Mfg. Co. No. 4520	55-199-998

RECEIPT OF EQUIPMENT

Equipment should be thoroughly inspected upon receipt. If equipment is damaged in any way, a claim should be filed with the carrier. Include pertinent data on equipment and details of damage as stated in the warranty. Forward one copy of the claim to Varian Associates.

WARNING

DO NOT ATTEMPT TO OPERATE DAMAGED EQUIPMENT!

If equipment has received no apparent physical damage but fails to function properly, proceed as indicated in the Warranty Statement. Varian Associates will assume all shipping costs in addition to liability under the warranty terms if notification of fault is received by Varian Associates within two weeks from the date of receipt of equipment by the customer.

ADDRESS

Address all communications regarding warranty, operation, service, and parts to:

Varian Associates
Instrument Division
Service Engineering
611 Hansen Way
Palo Alto, California

Include model, serial number, and date of purchase if known.

SERVICE POLICY

Varian Associates has established a policy that equipment sent in for service will be completely checked in addition to correcting the cause of the malfunction. Equipment shipped to the user will meet the specifications under which it was originally sold.

When it appears that it will be unusually expensive to bring an instrument up to specifications, the Service Engineering Department will contact the user for specific instructions.

WARRANTY STATEMENT

Recorder products manufactured by Varian Associates are warranted to be free of defects in materials and workmanship. Liability under this warranty is limited to service or adjustment of any equipment returned to the factory for that purpose and to making good at our factory any part or parts of the equipment.

Expendable parts, i.e., mercury cells, fuses, vacuum tubes, are excluded from this liability. This warranty is effective for a one year period beginning with the shipping date of the equipment.

Terms of the warranty are: (1) notification of the malfunction or irregularity must be received by Varian Associates or by the authorized Varian representative within the warranty period; (2) the equipment must be determined by Varian Associates or its representative to have become defective through no fault of the user. When notifying about the malfunction be sure to include a full description of difficulties encountered, the model and serial number of the equipment, from whom purchased, and date of equipment. On receipt of shipping instructions, ship the equipment by Railway Express, Air Freight or motor van, prepaid, to the address specified. If the fault has been caused by misuse or abnormal operating conditions, an estimate of repair costs will be submitted before the work is undertaken. Return shipping costs will be billed.

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VARIAN ASSOCIATES
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